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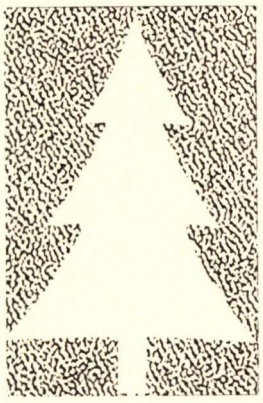
INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION
FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE
OGDEN, UTAH
JOSEPH F. PECHANEC, DIRECTOR

# Annual Report
# 1962



INTERMOUNTAIN FOREST AND RANGE
EXPERIMENT STATION

Joseph F. Pechanec, Director
Ogden, Utah

U.S. Department of Agriculture
Forest Service

# preparing for more intensive research

The Annual Report usually is largely confined to presenting highlights of research results and changes and other features of our program in which you might be interested. This year, before presenting these formal items, I wish to point out some important changes that have been taking place recently--in our people, where they are located, and the facilities and equipment with which they work.

Today's science is much more intensive, more specialized, and more costly than it was even a decade ago. This is just as true for the many aspects of research on forest and range lands in which we engage as it is of space, medical, or other broad fields of research.

To produce efficiently the kind of research results now needed, and to keep pace with the scientific world surrounding us, our personnel must be better trained and must have more adequate facilities for their work. We recognized this dual need several years ago, and have been making important progress toward filling it.

Through increased formal training, our professional staffs are becoming better prepared to conduct the kinds of research we need. Ten years ago 39 percent of our scientists had either masters' or doctoral degrees. Today, 71 percent hold advanced degrees, and 20 percent have doctoral degrees. In addition, 17 percent are now taking graduate courses to improve their abilities. Our staff represents a far wider range of skills than it did 10 years ago. From 7 classifications of scientists, we have moved to 16. Even more specializations than this are represented because our research foresters and range conservationists with graduate degrees show a wide variety of specializations.

By providing our scientists more help, we allow them to use their talents and training to much better advantage. During the last 10 years the ratio of supporting staffs to scientists has increased from 2:3 to 1:1. We have not yet gone nearly far enough in this, but we are progressing, especially in the matter of releasing scientists from loads of administrative work.

We have improved the scientific environment for a large portion of our men. Through the excellent cooperation of the universities in our territory, six of our seven major field headquarters are or soon will be located on or adjacent to campuses. This change provides our field men with a better scientific environment, excellent library facilities, and improved opportunities for cooperation and coordination with university research programs.

We have made a good start in providing our scientific personnel with the types of offices, laboratories, and equipment they need for first-class research. The Northern Forest Fire Laboratory at Missoula is an outstanding example. During 1962, we completed a new office-laboratory at Bozeman, and one under construction at Moscow will be completed early in 1963. In 1962, funds were appropriated for part of the needed office-laboratory facilities at Logan, Utah.

A counterbalancing and unwelcome item is the more-than-doubled cost of our research per professional man. The changes reported above, the acutely increased competition for well-trained men, the acquisition of improved facilities, and the general increase in all costs--all these and other factors are responsible.

In reviewing progress of this nature, we must guard against becoming enamored of mere physical and organizational changes and against holding these up as measures of progress in research. All would be little more than status symbols if they failed to contribute to the amount and quality of information we are providing to resource managers. However, there are clear indications that our progressive changes are paying off, even though most have not been in effect very long. In this we can take justifiable pride!

Joseph F. Pechanec

Director

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# forest management research

Although this Station and other research agencies have directed much attention to forest regeneration by both natural and artificial means, regeneration still is our most serious silvicultural problem. In fact, it is the object of the major part of our forest management research effort. In the western white pine, western larch, and ponderosa pine forest types our present research on regeneration is focused on artificial regeneration. These studies are making substantial progress. In lodgepole pine our regeneration research is concerned primarily with the problems of natural regeneration and here, too, progress is most encouraging. We have been unable to stretch manpower to study regeneration in two forest types, Engelmann spruce and interior Douglas-fir, that have serious regeneration problems.

Much of our remaining forest management research is directed to the problem of determining the production potential of a wide range of existing stands under different management treatments. Past research has given us considerable generalized knowledge of the problem but now we need more precise information. Though precise answers come slowly because of the very nature of the problem, our research is pointed toward giving these answers; and, again, progress is encouraging.

The following sections, one for each of our research projects, highlight recent accomplishments.

## SILVICULTURE OF WESTERN WHITE PINE

### Natural Regeneration in the White Pine Type

Studies of progress of natural regeneration over periods up to 20 years have emphasized several important factors to be considered in planning harvest cuttings in forests containing western white pine and associated species. These studies included seed tree, shelterwood, and strip-clear cutting methods on a variety of aspects at the Deception Creek Experimental Forest in northern Idaho.

On favorable aspects (east through north to west), reproduction of white pine is generally adequate within 10 years (fig. 1) and the adjacent or residual trees providing seed can be removed. On drier slopes, reproduction is slow and may be inadequate even 20 years after the first cut. Although the experiments were designed to favor white pine establishment, regeneration trends of associated species under these conditions are also interesting. Stocking of all species on northerly slopes was increased by about 25 percent over that for white pine alone, largely by extensive reproduction of western hemlock. On southerly slopes, regeneration of grand fir and Douglas-fir approximately doubled the stocking of white pine alone.

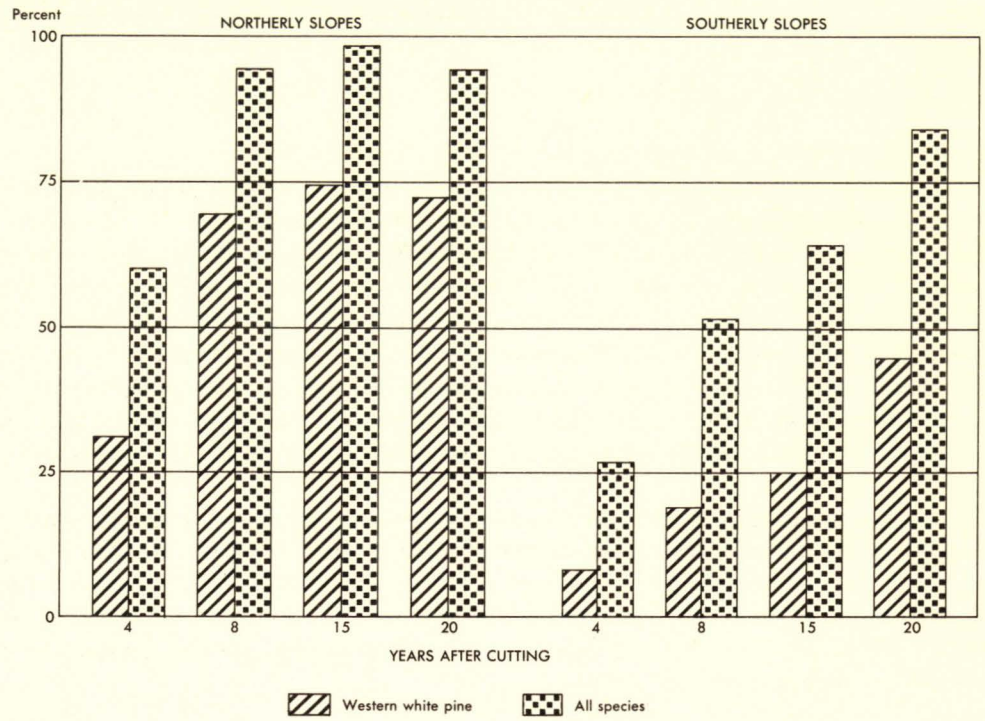



Figure 1.--Progress of natural regeneration on northerly and southerly slopes, Deception Creek Experimental Forest.

Natural regeneration of western white pine may be delayed by early blister rust infection and by later competition from more aggressive brush and tree growth. Because of economic advantages, clear cutting followed by prescribed broadcast burning and planting is the preferred method of white pine regeneration. Eventual production of genetically rust-resistant seedlings and, possibly, antibiotic immunization of nursery stock promise to make planting an even more attractive method.

## Flower Induction and Stimulation in Western White Pine

Strobilus induction and stimulation in western white pine trees in northern Idaho were attempted in four experiments begun in 1955 and 1956 employing grafting and various combinations of cultural treatments. No marked increase in flowering was observed in any experiment. In one experiment top grafts were made in 15 young trees (aged 7 to 12 years) at each of two localities in northern Idaho and western Washington. Although no flowering was observed in grafts of stock trees in northern Idaho, both grafts and stock trees produced female and male strobili at the western Washington localities. However, the five female strobili produced at the western Washington plots aborted.

Despite these failures in flower induction and stimulation, the treatment that combined cultivating, watering, and fertilizing effectively increased the size of western white pine seedlings (see 1961 Annual Report, p. 2); this hastens onset of the ripeness-to-bear stage of physiological development and makes this treatment the most promising method of accelerating strobilus production in western white pine seedlings and grafts.

## Selfed Western White Pine Seedlings Exhibit Slow Growth in Field

Seedlings resulting from controlled self-pollinations are characteristically slower growing in the nursery than seedlings from cross pollinations of the same female parent tree. Results from field plantings confirm the continued slow growth of outplanted selfed seedlings.

Total height growth of western white pine seedlings resulting from selfing and outcrossing of the same female parent trees was measured at age 9 years at each of two outplanting sites in northern Idaho. Average height growth of from two to six outcross progenies was compared with the average growth of seedlings from the selfed parent tree. Self-outcross comparisons were possible for five low elevation female parents (ca. 2,900 ft.) and four high elevation female parents (ca. 5,000 ft.). Height growth was markedly less for both low and high elevation selfs than for the corresponding outcrosses (fig. 2). Also, high elevation selfs grew more slowly than

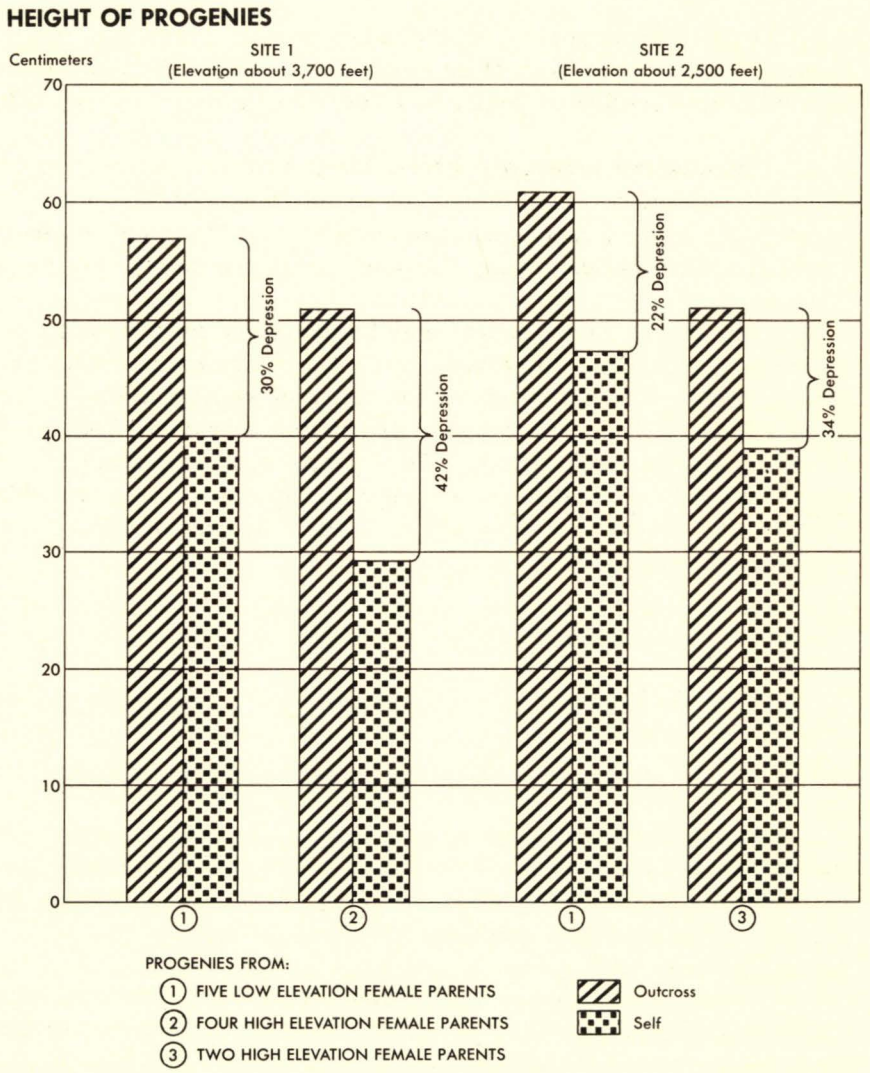



Figure 2.--Comparison of total height growth of 9-year-old self- and outcross progenies.

low elevation selfs relative to their corresponding outcrosses at the low and medium elevation outplanting sites. Part of this difference, however, was probably due to the use of low elevation trees as male parents in several outcrosses.

The markedly slow growth of selfed seedlings underscores the importance of eliminating small, runty seedlings in nursery operations and the avoidance of seed collections from open grown stands and from trees that increase the likelihood of self-pollination.

### Insects Destroy Western White Pine Cones

Cone insects caused severe losses to cone crops of western white pine in two areas in northern Idaho. The western pine cone beetle, Conophthorus monticolae Hopkins, was chiefly responsible for destroying more than 90 percent of the cones on 12 trees from one area during a 6-year period.

At the Cathedral Peak seed production area, larvae of two cone moths, Eucosma rescissoriana Heinrich and Dioryctria abietella (D. & S.), infested 19 percent of the cones on 54 trees in a relatively good seed year and 78 percent in the following, but relatively poor, seed year.

The western pine cone beetle attacks immature cones in the early spring, causing cone deformity and abortion that usually result in loss of the entire cone. Cone moth larvae feed indiscriminately on cone scales and seeds from June to September as the cones mature. Some cones are entirely destroyed, but most cones are only partially damaged.

Loss due to these insects may by prevented by tying a cloth bag over the immature cones in the early spring. However, the total effect of cone and seed insects on seed production (hence regeneration) throughout the range of western white pine may be considerable. Their impact in seed orchards and seed production areas will become especially critical as more of these areas are established. We urgently need much more information about the nature and extent of cone and seed insect damage throughout the western white pine type, the biology of the insects that cause this damage, and the relations of insect attack to the environment and to management practice.

## SILVICULTURE OF PONDEROSA PINE

### Logging Damage to Advance Reproduction

Regeneration of logged ponderosa pine stands in the Intermountain Region is often a difficult and expensive operation. Therefore, occurrence of advance reproduction as an understory is a very valuable asset. Where it occurs in sufficient amount and is given reasonable protection, it will insure establishment of the future stand. The great value of advance reproduction emphasizes the need for care in logging the overstory to avoid excessive damage to the understory. The initial logging in an experiment of single tree and group selection cuttings in ponderosa pine on the Boise Basin Experimental Forest near Idaho City, Idaho, in 1953 and 1954 gave opportunity to measure logging damage to advance reproduction and to pole stands as affected by different cutting methods and two sizes of logging tractors.

Heavy cutting caused significantly greater damage to the understory than light cutting. Damage was nearly the same for stands marked by group selection and stem selection, logged by large and small tractors, and with original overstory volumes of 10,000 to more than 20,000 board feet per acre.

The careful planning and supervision of the cutting may have been largely responsible for the negligible differences between results of all the treatments. In fact, a most important conclusion from the study is that if a logging job is thoroughly planned and closely supervised, none of the logging and management methods tested need result in excessive damage to advance reproduction in typical ponderosa pine stands in central Idaho.

## Racial Variation in Ponderosa Pine

Much of the speculation and some of the definite information about the effect of seed source and inheritance in forest trees have come from provenance studies. Until more precise studies develop, these often furnish the best estimates we have of the genetic variability existing within a species.

Two provenance studies of ponderosa pine in the Northwest have advanced to the stage where results can be presented with much more confidence than heretofore. In these experiments, seeds were collected from widely separated localities within the natural range of ponderosa pine and were planted in various areas within the Northwest. One of these, involving a single plantation in northern Idaho, was begun in 1911 by the Priest River Forest Experiment Station (now a part of the Intermountain Forest and Range Experiment Station). The other, involving five plantations in Oregon and western Washington, was begun in 1926 by the Pacific Northwest Forest and Range Experiment Station.

We cooperated with the Pacific Northwest Station in analyzing the many years of measurements and reporting on the results of these provenance studies.

Results proved that inherent differences in rate of height growth exist among trees in various regions of the range of ponderosa pine. Approximately 36 percent of the variation in total height among trees within a plantation was found to be due to seed source. Growth rates seemed to increase as clines going from east to west, and from south to north in the eastern portion of the range of the species. Evidence of an altitudinal cline, with increasing growth rate going from high to low altitude was also shown. No strong latitudinal effect was apparent in the west.

Height growth of progenies was most strongly correlated with the following climatic variables of the seed source localities: moisture distribution (expressed by September-through-June precipitation as a percent of annual) ($r = 0.54$ to $0.81$) and mean April-May temperatures ($r = 0.37$ to $0.82$). Growth was also correlated with absolute September-through-June precipitation ($r = 0.36$ to $0.73$), but to a lesser extent than the relative measure. Most of the fastest growing trees were from localities having high proportions or absolute amounts of September-through-June precipitation and high April-May temperatures. The strong longitudinal cline was largely associated with moisture distribution, while the altitudinal and latitudinal clines were largely associated with April-May temperatures.

# SILVICULTURE OF LODGEPOLE PINE

## Seedbed Preparation for Regeneration

We now have first-year results from a study of nine methods of seedbed preparation. This study was made to determine what method of seedbed preparation provides optimum conditions for germination and survival of lodgepole pine on problem areas near Island Park, Idaho, and West Yellowstone, Montana. Seedling counts were made frequently throughout the 1962 growing season. Measurements of soil moisture and on-site weather data were also made to aid in determining causes of mortality.

The nine seedbed treatments included in the experiment are:

1. Control. Natural undisturbed duff.

2. Burning. Burning with no attempt to expose mineral soil.

3. Scalping. Stripping off all vegetation.

4. Scalping and cultivating. Stripping off all vegetation and cultivating to a depth of 6 inches.

5. Furrowing. Trenching 3 to 4 inches deep; soil is thrown to one side leaving a sharp perpendicular edge to the south to provide shade.

6. Trenching. Trenching 3 to 4 inches deep; V-shaped trenches have a 45° angle to both north and south and thus provide no shade.

7. Simulated "Fleco" trenching. Partial scalping followed by trenching; trenches 1 to 3 inches deep and about 16 inches apart.

8. Scalping, cultivating, and spraying. Treatment 4 followed by spraying with Dalapon at recommended rate per acre.

9. Disking. Disking with a lightweight disk harrow.

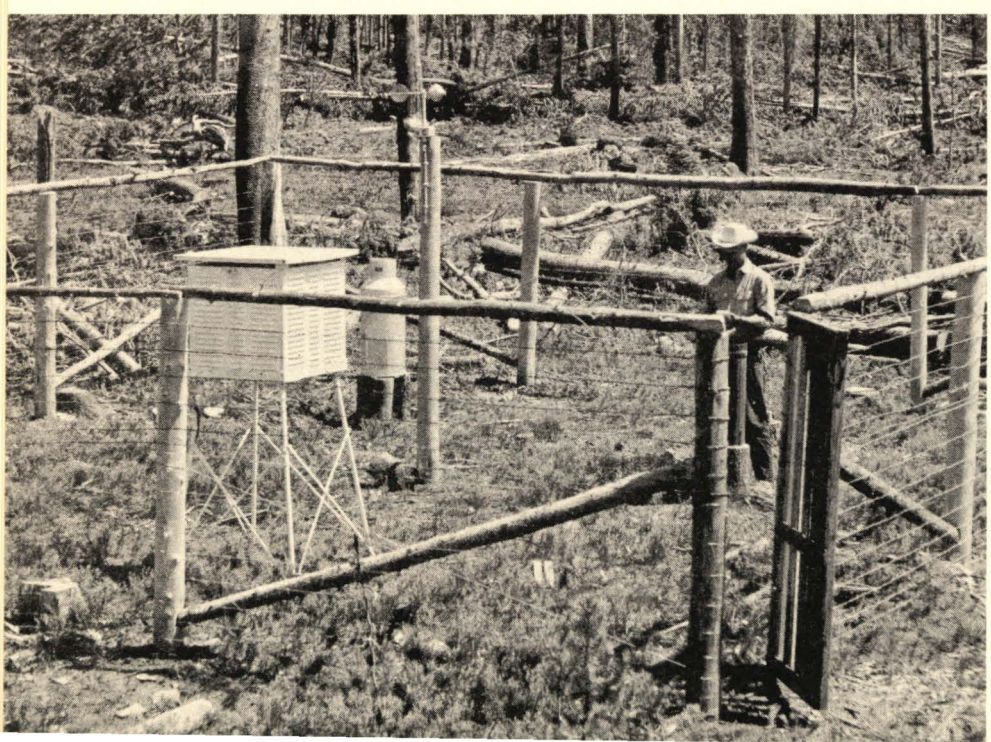


Figure 3.--Collecting on-site weather data near Moose Creek Plateau seedbed preparation plots. Recording instruments measure precipitation, air and soil surface temperatures, relative humidity, and wind.

Treatments that provided best conditions for germination did not necessarily provide the best conditions for survival. The following tabulation for the Island Park area ranks the scalped-cultivated-sprayed treatment sixth in total number of germinated seedlings, but percentage of survival was best under this treatment.

| Treatment | Germination of seedlings per milacre (number) | Survival (percent) |
|---|---|---|
| Scalped-cultivated-sprayed | 75 | 94 |
| Scalped-cultivated | 82 | 88 |
| Simulated "Fleco" brush blade trenched | 123 | 82 |
| Scalped | 99 | 76 |
| Trenched | 105 | 74 |
| Furrowed | 122 | 67 |
| Disked | 47 | 58 |
| Control | 45 | 37 |
| Burned | 39 | 13 |

On the Island Park Flat, larger numbers of seedlings survived under some type of east-west oriented trenching (simulated "Fleco" blade, V-trenching, or furrowing) than under other treatments, partially because of better germination. Treatments that included scalping (scalping, scalping-cultivating, scalping-cultivating-spraying) were nearly as effective as cross-trenching. Both germination and survival were low on the disked, burned, and control treatments.

## Site Evaluation

Field work for Intermountain Station's site evaluation study in cooperation with the Rocky Mountain and Pacific Northwest Forest Service experiment stations was completed this year. The main objective of this study is to develop indexes for rating the productive capacity of lands where lodgepole pine is growing. Site index curves will be prepared for base ages of both 50 and 100 years. Dominant tree height and age are the principal factors being used in setting up the rating scheme. However, a novel feature of the system is the inclusion of stand density as a critical variable for interpretation of dominant tree heights.

For the portion of the sample in the Intermountain and Northern Rocky Mountain Regions, 400 dominant trees were felled at 33 locations in stands 30 to 210 years old. Each tree was the center of a circular plot for which stand density was measured. A cross section was cut at successive heights along the bole of each tree for age determinations. These cross sections will also be used to advance our research in wood specific gravity of lodgepole pine in its distribution throughout the Station territory. In addition, measurements of crown length and diameter increment have been taken from each felled tree. Results from these measurements when analyzed and interpreted will add to our knowledge of growth relationships for this tree species.

## SILVICULTURE OF WESTERN LARCH

### How to Increase Success of Spring Seeding

Prompt regeneration of western larch is essential to keep cutover stands in full production and to prevent other vegetation from dominating the cutover area. Direct seeding can be used to regenerate some cutover areas. A study comparing germination and survival of stratified and nonpretreated seeds sown in spots was made on the Coram Experimental Forest beginning in the spring of 1960. Three procedures increased the number of surviving seedlings:

1. Stratifying larch seed for 1 month before sowing in the spring.
2. Sowing the larch seed only on northerly aspects.
3. Waiting until snowmelt is finished on the north slopes before sowing the stratified seed.

### Stand Development

Seedlings established on a mineral soil seedbed show superior height growth for as long as 15 years after establishment. This is demonstrated by a study of stand development in the larch type on the Coram Experimental Forest. Following a seed-tree harvest cutting, we established four different seedbeds. We slashed the residual understory (mainly of subalpine fir and tall shrubs) on half of the logged-over area and left the other half intact. We exposed mineral soil on part of each of these two areas and left the remainder of the forest floor intact. We then recorded the development of seedlings that established themselves on these seedbeds. The following tabulation shows the average 5-year height growth of the dominant seedlings, predominantly western larch with lesser amounts of Douglas-fir, lodgepole pine, subalpine fir, and Engelmann spruce, during the period 10 to 15 years after treatment, on each of four seedbed conditions.

| Treatment | 5-year height growth (feet) | |
|---|---|---|
| 1. Mineral soil; understory not slashed | 6.2 | [1] |
| 2. Mineral soil; understory slashed | 5.5 | [1] |
| 3. Forest floor; understory slashed | 4.3 | [1] |
| 4. Forest floor; understory not slashed | 2.0 | |

[1] The means bracketed by any one line do not differ significantly at the 1-percent level of testing.

This study shows keen competition between young trees and other vegetation in the larch type. Site preparation that produces a mineral seedbed not only favors establishment of natural regeneration, but it reduces competition and thus also favors development of the young seedlings.

### Timber Management Problems in Western Montana

We assisted the Station's Division of Forest Economics Research in appraising the timber management job involved in increasing production on National Forest lands in the 10.4-million-acre Clark Fork drainage of western Montana. The study attempted to bring the timber problems and potentials of the area into focus and to describe the broad programs needed to utilize the timber growing potential of the area.

The task of developing a program to increase forest production in this area is complex not only because of the large number of stands involved but also because some difficult problems must be solved in managing the growing stock nature has provided. Most stands have too many trees; the rest have far too few. Timberland in this part of the United States has a much higher productive capacity than most foresters realize, but the natural unmanaged forest is an inefficient timber producing unit. Unless substantial effort is put into cultural work, future timber yields are likely to be disappointingly small and of poor quality.

## MENSURATION

### Growth, Yield, and Quality of Forest Products

Growth and yield of grand fir now can be estimated in pounds of dry fiber by using results of a study conducted in cooperation with Potlatch Forests, Inc., Inland Empire Paper Company, and the Forest Products Laboratory. Tree weight is determined from measurements of height, diameter, crown class, and specific gravity of an increment core extracted at breast height. Average tree specific gravity and the specific gravity of periodic increment also can be estimated by equations based on these tree characteristics. These equations provide the basis for summarizing plot data from a grand fir growth study now being analyzed.

### Inventory Methods

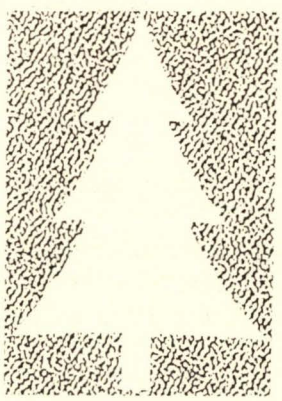
Silvicultural prescriptions for forest stands require detailed information about the potential crop trees. To obtain this information, several sampling rules have been devised. Of necessity, these sampling rules incorporate certain silvicultural decisions on the character and desirable spacing of crop trees.

A study started in 1962 in cooperation with the Division of Forest Economics and Recreation Research of this Station, and Region 1 of the U.S. Forest Service, will permit evaluation of such sampling rules incorporating alternative silvicultural decisions. Fourteen stands were stem-mapped and each tree described. These stand data will be entered into an electronic computer. A computer program based on the logic of the sampling rules will provide an intensive sample of the mapped stand according to each rule. Analysis of the characteristics of the crop trees selected by each rule will give a basis for selecting their best features to provide a still better means of obtaining silvicultural data for managing forests.

## Automatic Data Processing

The mensuration project was moved to Moscow, Idaho, in September. The new location permits more efficient use of the excellent computer facilities available at both Washington State University and University of Idaho.

During the year, two computer programs were prepared as working tools for the mensuration project. One is a general regression program specially written to include covariance analysis. The second is a summary program for permanent sample plot data. This latter program will speed the study of growth on about 30,000 tagged trees for which periodic measurements have been recorded for up to 50 years. The new program advantageously uses computers to speed up work that has been carried out on punched-card equipment since 1928.



# forest disease research

Forest disease research started its 1962 work program under a reorganized system of three projects:

Native rusts of western conifers (Logan, Utah).

Development of western white pines genetically resistant to white pine blister rust (Moscow, Idaho).

Diseases of western white pine and associated tree species, and physiological action of antibiotics in tree disease control (Spokane, Washington).

By the end of 1962, about 50 percent of the research effort in these projects was directed toward fundamental studies in host-parasite relations, host genetics as related to resistance, and physiology and cytology of several important tree diseases.

## NATIVE RUSTS OF WESTERN CONIFERS

### Broom Rusts Retard Hosts' Growth

Yellow witches'-brooms caused by Melampsorella in fir trees and Chrysomyxa in spruce trees are often associated with mortality, killed tops, and wind breakage; but no measure of retarded growth in infected trees has been reported previously. A study using paired broomed and healthy trees (65 pairs of trees with matched diameters) showed that brooms themselves, in trees without trunk damage, are associated with growth reduction. Six study plots were established in Utah, Wyoming, Idaho, and Montana. Although the average diseased subalpine fir trees in the study plots had three times as many rust infections as the Engelmann spruce (9 vs. 3), the growth reduction was greater in spruce. Height growth during the last 10 years was a significant 25 percent less in broomed than in healthy spruce. Ring measurements on stumps showed that broomed spruce averaged 19 percent faster growth in diameter than its healthy counterpart up to the time of the first rust infection; but average increment of the infected trees was 21 percent less than that of healthy members of the pairs during the decades since their first infection. Growth differences in fir in this study were not statistically significant; but height growth averaged 11 percent less in the broomed trees than in healthy ones during the last decade.

Figure 4.--Fir broom rust in subalpine fir caused by Melampsorella caryophyllacearum: A, Trunk swelling, a result of growth stimulation by rust mycelium that has spread from a branch infection into the trunk; B, multiple branch infections in the crown, shown by the witches'-brooms, have killed this tree.

## BLISTER RUST RESISTANCE

### Biochemistry of Resistance

The study during 1962 of the comparative biochemistry and physiology of western white pines resistant and susceptible to blister rust has emphasized analysis of the polyphenolic compounds in needle and living bark tissue. One unidentified phenolic compound has some association with resistance to the blister rust fungus.

### Breeding for Rust Resistance

Previous reports of Intermountain Station's program for breeding blister rust resistant western white pines have emphasized that a practical product is in sight. This product is nursery stock, two generations removed from the original resistant parents; about half of this nursery stock should be able to withstand intense exposure to the rust disease. This stock can be mass-produced in grafted seed orchards; initial seed production probably will be attained shortly after 1980. Attainment of this practical goal is considered sufficiently important to justify a shift in program emphasis now from fundamental research on the "how" and "how much" of inheritance of rust resistance to attempting to convert research findings to practical use.

Routine pollination, seed handling, artificial inoculation, and progeny testing have been considerably streamlined. Even so, overall annual project workload, judged by routine field operations, has increased fourfold: from 600 to 2,500 pollinations; from 100 to 400 seed lots; and from 250 to more than 1,000 lineal feet of nurserybed progeny tests, all to be inoculated and examined.

Tree selection was somewhat reduced in 1962. About 20 new rust-free trees were located in heavy infection centers of blister rust in Boulder Creek on the Kaniksu National Forest and in Elk Creek on the St. Joe National Forest. The total number of rust-free tree selections is now nearly 370--only 30 short of the objective of 400 that will be required to meet minimum specifications for the seed orchard program.

### Seed Orchard Technology

A second replicate of the 100-tree, early spring, field grafting experiment (see Annual Report for 1961, p. 9) confirmed earlier results. Scions from the same 10 ortets used in 1961 were whip grafted in late March and early April on 10 different rootstocks. Nearly 75 percent of the grafts survived and grew. Other studies on early spring outdoor grafting, using cleft grafts and omitting grafting wax, showed that these methods of grafting are faster and more economical than whip grafting. A study of time of grafting showed that grafts made as late as 6 weeks after the start of rootstock bud elongation (about April 13) are successful. This means that the spring, outdoor grafting season can extend for 6 to 8 weeks, and that smaller and more highly trained crews can be used in establishing grafted seed orchards.

Grafted trees used to establish the Sandpoint Experimental Seed Orchard have been closely observed since the original grafting of 3,250 trees in 1959. The grafting was designed so that a valid test of clonal variation could be made for this characteristic and for others in the future. As a result, this 13-ortet orchard was laid out in randomized complete blocks and will be an outdoor laboratory for tree research while providing blister rust resistant seed.

Results obtained from periodic measurements of graft survival and growth may be summarized as follows:

1. Individual western white pine trees vary in graftability.

2. Early incompatibility is apparent in different degrees or types.

3. Incompatibility may appear in spite of initial grafting success.

4. Such factors as elevation, and height at which scionwood is collected in the crown of ortets, have negligible influence on graft survival during the first 2 years. However, vigor of an ortet influences survival of its ramets.

## ANTIBIOTIC RESEARCH

### Antibiotic Screening

Twenty-two antibiotics were screened at concentrations of 1, 10, and 100 parts per million using 37 forest tree fungi growing in culture on artificial media. Several chemicals proved effective against organisms in culture at a concentration of 1 p.p.m. In the antibiotic screening on cultured parasites, differentiation between inhibition and killing was detected by transferring the inoculum to antibiotic-free culture medium.

### Aerial Spray Test on Comandra Rust

First examination of the large-scale tests of antibiotic control of comandra rust on lodgepole pine was made in 1962, 1 year after the study plots had been aerially sprayed. Most of the 4-acre plots had been sprayed with the semicarbazone formulation of cycloheximide at concentrations of 200, 300, and 400 p.p.m. at rates of 5 and 10 gallons of spray per acre. One plot was also sprayed with 400 p.p.m. of the methyl-hydrazone formulation at 10 gallons per acre. No control was detected; both aecial and pycnial sporulation increased, and canker growth continued on nearly all trees whether treated or untreated. Similarly, no control could be detected on trees where these antibiotic materials had been applied as basal-stem treatments in July 1961. All study trees will be examined again in 1963.

## HEART ROT STUDY

### Sporulation and Germination of Indian Paint Fungus

Sporophores of Indian paint fungus produced small quantities of spores shortly after cessation of typical winter conditions. However, the basidiospores did not germinate after 70 hours' incubation at 25° C. When sections of sporophores were mounted in various solutions, basidiospores germinated, septa were produced, and branched hyphae had grown as much as 133 microns in the first 70 hours. Evidence indicates that the basidiospores are nutritionally independent and that their viability is controlled by a narrow range of moisture requirements.

## DWARFMISTLETOES [1]

### Seed Storage, Germination, and Viability

Studies designed to determine satisfactory storage conditions for dwarfmistletoe seed reveal that the seed of Arceuthobium douglasii, A. americanum, A. campylopodum forma campylopodum, laricis, tsugensis, and abietinum, can best be stored in a well-ventilated incubator at 1° to 5° C. in 35 to 45 percent relative humidity. Seeds of these species retained 50 to 60 percent viability after being thus stored at 5° C. for as long as 235 days. Loss of viability during storage at 5° C. increases directly with time. Presence of light during storage does not affect viability and germination of dwarfmistletoe seeds.

Solutions of hydrogen peroxide (1 to 5 percent) are much more efficient in testing dwarfmistletoe seed for viability than the triphenyl-tetrazolium chloride staining method. The peroxide treatment results in direct germination of the seed within 3 to 8 days. Estimated viability is 6 to 8 percent lower by this technique than is obtained by using the triphenyl-tetrazolium chloride stain. However, the peroxide test gives an accurate measure of viability and provides a simple, rapid, and uniform method of germination.

### Inoculation of "Resistant-Forms" of Douglas-fir

Seedlings of coastal Douglas-fir and seedlings taken from Douglas-fir stands in central Montana became infected when inoculated with dwarfmistletoe in the greenhouse. Dwarfmistletoe does not naturally occur in the coastal form Douglas-fir on the west side of the Cascade Mountains in Washington and Oregon north of the Siskiyou Mountains of southern Oregon, or in Douglas-fir stands of central Montana. Results of inoculations at Pullman reveal that susceptibility, host symptoms, and development of the parasite are no different in these seedlings from what is found in seedlings of the intermountain form of Douglas-fir.

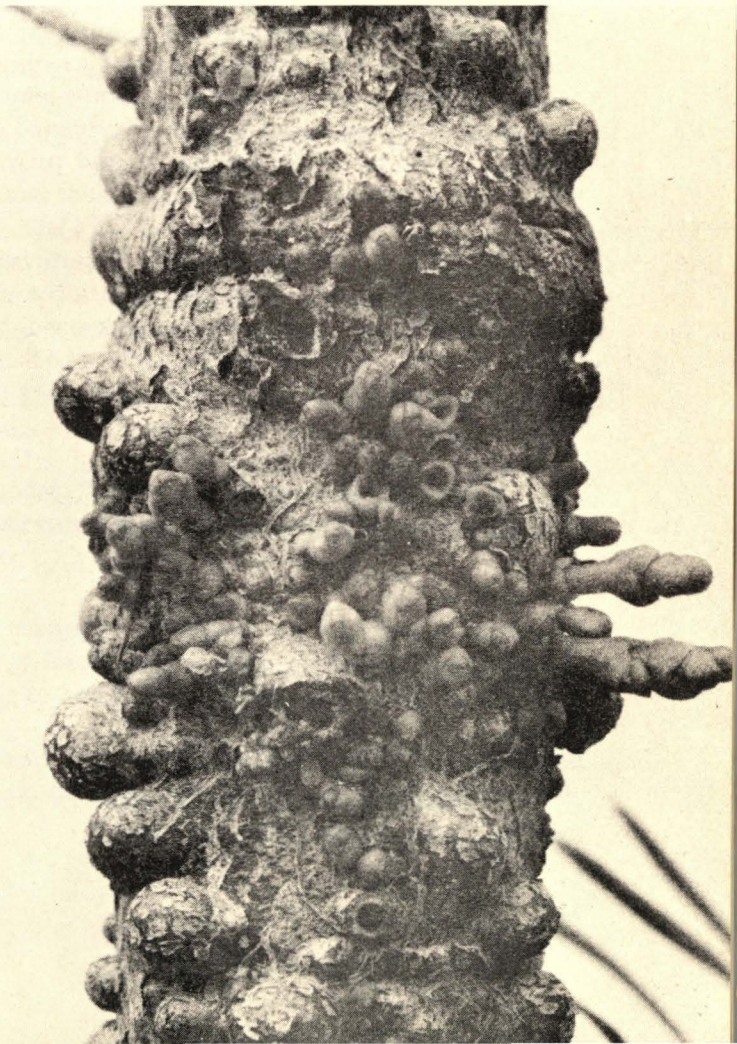


Figure 5.--Shoots of dwarfmistletoe on the coastal form of Douglas-fir following artificial inoculation of 3-year-old seedlings.

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[1] Results of dwarfmistletoe research reported here are from cooperative studies between the Department of Plant Pathology, Washington State University, Medical and Biological Project 1490, and the Intermountain Station.

### Fungal Parasites of Dwarfmistletoes

The fungus Colletotrichum gloeosporides was found on western larch dwarfmistletoe plants along Sherman Creek in the Colville National Forest and on western hemlock dwarfmistletoe plants in the Cascade Mountains near White Pass, Washington. This is the first report of this fungus parasitizing dwarfmistletoe plants in the Pacific Northwest.

An apparently undescribed species of Pestalotia was found on true-fir dwarfmistletoe plants in the White Pass area. This same fungus was isolated from molding seed of the western hemlock dwarfmistletoe collected near North Bend, Washington. This constitutes a new host record for the genus Pestalotia. However, it is doubtful if this fungus is pathogenic.

### New Host for Larch Dwarfmistletoe

Arceuthobium campylopodum f. laricis was found infecting Norway spruce, Picea abies, at the Priest River Experimental Forest in northern Idaho. This is a new host record for larch dwarfmistletoe.

## OTHER DISEASES

### Elytroderma Twig and Foliage Disease [2]

In study of the life cycle and site of host invasion of Elytroderma deformans, tritiated uridine was incorporated into the cytoplasm of vegetative hyphae and of the plectenchyma layer of the parasite's hysterothecia growing within the needles of ponderosa pine. The label readily entered hyphae in the resin canals, mesophyll, phloem, xylem, and transfusion cells of the pine needle. Attempts to introduce tritiated thymidine in a similar fashion gave inconclusive results. The use of $H^3$ uridine should provide new information on the location of hyphae within host tissue and help elucidate host parasite relations.

Except for infection studies, laboratory investigations on the life cycle of Elytroderma have been completed. Cytological studies of many physiologically different isolates of the fungus showed that a changing nuclear condition (from multinucleate to binucleate to uninucleate) in the systemic and the sporocarpic-producing hyphae occurs in both cultures and living material. This nuclear condition is the key to revealing the major part of the life cycle of the fungus.

Field observations in 1962 confirmed belief that humid summers provide a favorable environmental condition necessary for production of ascospores.

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[2] Studies conducted at the Botany Department of Montana State University through Forest Service Cooperative Agreement 680-2.

# forest economics and recreation research

## ECONOMICS RESEARCH

The Station's program in economics research consists of four projects, with five distinct activities. The twofold program of Forest Survey includes (a) collection and interpretation of timber survey data for eight Mountain States and South Dakota, and (b) techniques research. The other three projects are studies of the economics of timber growing and protection; marketing studies; and multiple-use studies. All but the multiple-use economics study have been underway for some time.

### Forest Survey

The Forest Survey staff continued its effort to improve the quality of inventory data and the techniques for gathering them. Two new studies were started this year.

One is a comparison of sampling procedures for collecting management data from forest stands. The division of Forest Management Research is actively cooperating with Survey on this project. One important question to be answered is whether a sampling system based on a grid of small fixed-radius plots better describes the management situation in an individual stand than a system based on a grid of variable-radius plots. These two techniques are being tested in sample stands that have been silviculturally marked and in which all trees have been surveyed in-place.

The other project is a techniques study to develop criteria for subdividing commercial forest land. This study is designed to provide guidelines for partitioning commercial forest land into classes that reflect the relative ease or difficulty of producing or harvesting successive crops of timber, with particular attention to potential effects of logging operations on watersheds.

Photogrammetric research has been perfecting photo measurement techniques and training methods for Forest Survey and other activities related to inventory of range and wildlife habitat, potential recreation areas, and watersheds. Photo techniques for measuring lakes and streams for wildlife habitat inventory were demonstrated and used at the annual Utah Fish and Game Department short course at Utah State University. These techniques were devised and developed in connection with a cooperative recreational study with Utah State University.

Aerial volume tables for pinyon-juniper in terms of cubic feet and fenceposts have been completed and published. Composite volume tables for Rocky Mountain conifers compiled from nearly 500 Forest Survey field plots are now being tested for use in Regions 1, 2, 3, and 4.

During the year we redesigned an aerial photo-scale protractor and parallax wedge and designed a new bar type micrometer wedge that is valuable in measuring small distances on photos.

Inventory of the forests in Arizona and New Mexico was started in 1962. These are the last two of the 50 states to have their forests surveyed. Many of the data for Arizona and New Mexico come from recent inventories of the National Forests and Indian Reservations. A supplemental survey was conducted on these areas in 1962 to collect additional information. The area outside the National Forests was completely surveyed by the new multiple-point acre-sampling system. This technique provides standard items of inventory and also a means of classifying forest stands according to condition and management needs by including data on crop trees, excess and competing trees, and site and age.

The report on the forest resources of Idaho, published in 1962, brought together data for the entire State for the first time within one cover. The report included data from the second inventory of northern Idaho and from the first inventory of southern Idaho.

The 3-year Wood Density Cooperative Survey was completed this year. Timber inventory crews from the Forest Service's Northern and Rocky Mountain Regions and from this Experiment Station collected data and wood specimens from Idaho, Montana, Colorado, New Mexico, and Arizona. All of the information has been sent to the Forest Products Laboratory in Madison, Wisconsin, for compilation and analysis. During the past three field seasons more than 2,000 locations were sampled throughout the commercial forest area of the Mountain States as shown in the following tabulation:

| State | Sample locations |
|---|---|
| Idaho | 722 |
| Montana | 425 |
| Wyoming | 298 |
| Arizona | 184 |
| Utah | 171 |
| New Mexico | 109 |
| South Dakota | 87 |
| Colorado | [1] 25 |
| | 2,021 |

[1] Samples taken in Douglas-fir type only.

The increment cores collected in these and the other Western States will be used to determine geographic variations in specific gravity of the western softwoods. There is strong correlation between specific gravity and fiber yields and wood strength.

## Economic Studies

The economics research staff continues to cooperate with Forest Survey and the Forest Management Research division in searching for the kind of data that would provide more meaningful analysis of timber growing problems and opportunities. This year the staff also completed a study of the timber growing problem and opportunity on the north slope of the Uinta Mountains and started a study of white pine management on the National Forests of northern Idaho, northeastern Washington, and western Montana.

Intermountain Station was asked to take a new look at the opportunity to grow white pine on National Forests in Region 1. This request was occasioned by significant changes in the situation since 1948, when the Station made a detailed analysis of the white pine situation. Research to develop rust-resistant strains of white pine looks very promising. Moreover, development of antibiotics for treating infected white pines has altered the strategy of control. It has also reduced protection costs and apparently has released white pine growing from certain physical constraints. In other words, to the extent that antibiotic treatment proves as effective as anticipated, it no longer will be necessary to confine blister rust control of established stands to areas where topographic features restrict the movement of blister rust spores.

This economic study is being undertaken, therefore, to determine what reorientation of white pine management programs is feasible and desirable on the National Forests because of progress made in control methods. We would expect to answer questions such as:

- How has the use of antibiotics altered the geographic-unit concept of blister rust control? Is it now feasible to protect and grow white pine on areas outside of the present blister rust control zone?

- If the geographic-unit concept can be abandoned, what sort of organization of protection programs and priorities is desirable? In other words, should management units outside the existing protection zone be substituted for areas inside, or should the white pine program be expanded?

The question, "How large should the white pine program be?" was considered in detail in the 1948 study. However, since cost-price relations have changed, we must reconsider this issue, also taking into account (1) the costs and yields of white pine growing in contrast with the costs and yields for other species on the same area; and (2) the long-range market prospects for the several species that could be grown here.

Although the 1948 study stressed that blister rust control and silviculture should proceed hand-in-hand, it did not attempt to prepare detailed program alternatives, listing by periods the amount that should be spent in such individual activities as blister rust control, thinning, and planting to achieve specific production objectives. We propose to describe program alternatives indicating the sequence of actions that seems desirable for several different levels of activity. For example, we would be able to indicate the type of areas that should be included in a minimum white pine growing program, the sequence of yields that will be obtained from these areas, the pattern and amount of cost to protect these areas, and the pattern and the cost of desirable silviculture. The same thing will be done for other levels of operation.

## RECREATION RESEARCH

The report, "Recreation Opportunities and Problems in the National Forests of the Northern and Intermountain Regions," published this year, stresses four points: (1) Recreation development on the National Forests must be closely coordinated with that of other agencies and groups; (2) the contribution of the National Forests as outdoor playgrounds can be broadened by orienting proportionally more of the planning and development to national rather than local needs; (3) aggressive action is necessary to lessen human impact on more heavily used recreational areas; and (4) the recreational opportunity on public lands can be considerably enhanced by imaginative planning.

The photogrammetry section is developing improved techniques for inventorying water resources. A new procedure for inventorying recreational data was field tested on the north slope of the Uinta Mountains this year in cooperation with the School of Forestry, Range, and Wildlife Management of Utah State University. Preliminary analysis of aerial photo estimates of the surface area of water to a depth of 15 feet indicates that the proportion of shallow area for a series of lakes can be estimated by photo techniques about as reliably as it can be determined by field soundings, which cost 10 times as much. These new techniques can provide the land manager with better tools for estimating the extent, nature, and utility of the recreational water resource he must consider in his management planning.

A research specialist on our staff is assigned to lead the cooperative recreation research unit at Utah State University. He is stationed on the campus to permit him to guide graduate students in their research projects.

Figure 6.--Sheep Creek Canyon Campground on the Ashley National Forest, Utah, is a beauty spot typical of many on semiarid western land. Research seeks to extend recreational use of such spots without damage to land, water, and cover.

# forest engineering research

Research under this new program, announced in 1961, began early this year with assignment of a project leader to Bozeman, Montana, headquarters for this project. During 1962, all of the engineering research effort was devoted to these phases:

1. Making observations and collecting data on methods of harvesting and transportation now being used in the logging industry in this region.

2. Planning a long-range program for development of engineering systems for the logging industry.

3. Starting studies on the transport of wood in pipelines.

An important element in the progress and success of these and future studies is the wholehearted cooperation from the Engineering Division of Montana State College. This includes participation by faculty members and a graduate student program on projects related to forest engineering research. Many fields of research in forestry must necessarily become involved, and a successful program in forest engineering research can be achieved only through close coordination and cooperation with activities in these other areas.

## HARVESTING METHODS

A study of systems for harvesting and transporting timber is one of several broad subjects selected for investigation under this program. In this general region, where timber is typified by relatively small stems and low volume yield of wood per acre, and where much harvesting is on rough, steep terrain, costs of harvesting are high. Two-thirds to three-quarters of the price of timber delivered at the mill is involved in harvesting and transportation.

As a first step in developing a research program to investigate the problem and develop more efficient systems, data have been collected and observations made of a large number of logging operations. This information will be analyzed to determine which opportunities are likely to be most profitable for research. Faculty members from Montana State College, representing several subject disciplines in engineering, are participating in collection and analysis of information.

Field observations of woodland operations made so far have posed these questions: Should we shoot high and look for something completely new and different in equipment, methods, and procedures; or should we approach a research program on the basis of improving the economics of present methods? Will the program be a revolution or evolution?

Application of modern management techniques to forest operations, which includes development of efficient engineering systems, is complicated by several factors. First is the inherent complexity of the forest environment and the character of the material to be handled. Second is the absence of long-term management policy related to harvest methods. Others are poor communication and information networks, slow evolution of logging techniques, and lack of reliable records of costs of past and current operations.

Evidence gathered to date indicates that any change toward scientific methodology in production of wood from the seed or seedling, through the operations of harvest and transportation to the processing plant, would have a far-reaching impact upon present-day principles and policies of forest and wildland management.

## PIPELINE TRANSPORT

The Engineering Division of Montana State College entered into an agreement in April to continue the study of using pipelines for transporting chips and possibly small bolts. Preliminary studies in cooperation with the Station made during the latter part of 1961 showed that it is technically possible to employ such an installation as a potential part of an engineering system in getting wood from the stump to the processing plant.

These preliminary studies of the hydraulics of a pipeline system, completed late in 1961, showed that available hydraulic data are insufficient for the design and operation of such a system, assuming it were economically feasible. An estimate of the operating expenses, made as part of these initial studies, showed a pipeline could be competitive with the transportation methods now used. A more detailed economic analysis of a pipeline system was started in April on the basis of these results.

A mathematical model of the economics of wood chip transport in hydraulic pipelines was developed for the computer in the Numerical Analysis Laboratory of Montana State College. This program has been used to determine the cost per ton-mile for delivering bone-dry chips in pipes whose diameters vary from 6 to 20 inches and whose lengths range from 10 to 500 miles. It has been developed to give the most economical velocity of transport for each pipe for each length. Sixteen variables that affect the cost of a pipeline (in addition to the diameter, length, and velocity) have been included in this preliminary model. Each factor has a maximum, a minimum, and a median value based on the best estimate and actual cost data available.

The program has shown that:

1. The cost per ton-mile decreases as length of line increases.
2. The cost per ton-mile decreases as diameter of the pipe increases.
3. The most economical velocity for a given diameter decreases as length increases.
4. Wages, salaries, and operating costs are more significant than capital cost items on short lines than on longer ones.

This economic analysis has also emphasized necessity for basic research to obtain sufficient design data that may be converted into more reliable cost figures related to:

1. Pipe friction for the flowing wood chip-water mixture.
2. Maximum concentration capable of being transported.
3. Pumping systems capable of delivering required volumes at the desired heads.
4. Injection systems capable of mixing the required volumes at the designed solids concentrations.
5. Flow controls capable of metering and valving this type of mixture.

These studies have also indicated clearly that collecting the required volumes of material at pipeline input stations will require complete analysis of the harvesting methods and the necessary auxiliary transportation network needed to make a pipeline system operationally feasible.

# forest fire research

Forest fire research in 1962 started to bring several long-hoped-for methods for fire control closer to reality. Research at the Northern Forest Fire Laboratory is laying essential groundwork for electronic fire detection, diversified use of chemicals in suppression, better attack on lightning fires, new approaches to fire prevention, and improved ability to evaluate combustion factors, predict fire behavior, and use fire beneficially in resource management.

## FIRE CONTROL SYSTEMS

### Detection

In the Western States, fire detection systems must be especially efficient in rapid location of lightning-caused fires. Areas susceptible to sudden great outbreaks of such fires need detection and mapping systems that can (1) quickly identify zones of intense lightning activity, (2) concentrate observation in areas of known lightning strikes, (3) detect, locate, and map fires at night, and (4) detect, locate, and map fires through smoke. All detection methods now used are severely limited by dependence on visual observations.

Our research is attacking these problems by developing techniques for using electronic systems to identify lightning strike areas and heat-sensing devices to detect and map individual fires. A cooperative research project with Montana State College Electronics Research Laboratory is developing the prototype model of a sferics direction-finding system to track lightning storms. Gratifying progress to date in circuit design and assembly of components indicates that first field tests may be made during the 1963 fire season.

For precise location and mapping of fires we are developing methods using infrared heat sensors made available through the cooperation of the Department of Defense. One phase of this project is determining the feasibility of detecting small heat sources through several forest canopy complexes from varying elevations above the targets and various angles of view. The second phase is developing techniques for mapping of actual fires by airborne infrared scanners. Results of this research have already demonstrated capabilities for mapping fires either day or night or through dense smoke (fig. 7).

### Retardant Chemicals

Fire retardant chemicals have become accepted major agents in fighting forest and range fires. However, precise information about their interaction with various fuel, fire, and weather conditions has been needed in order to realize the full potential of each one. In cooperation with the Pacific Southwest Forest and Range Experiment Station and several other agencies, the

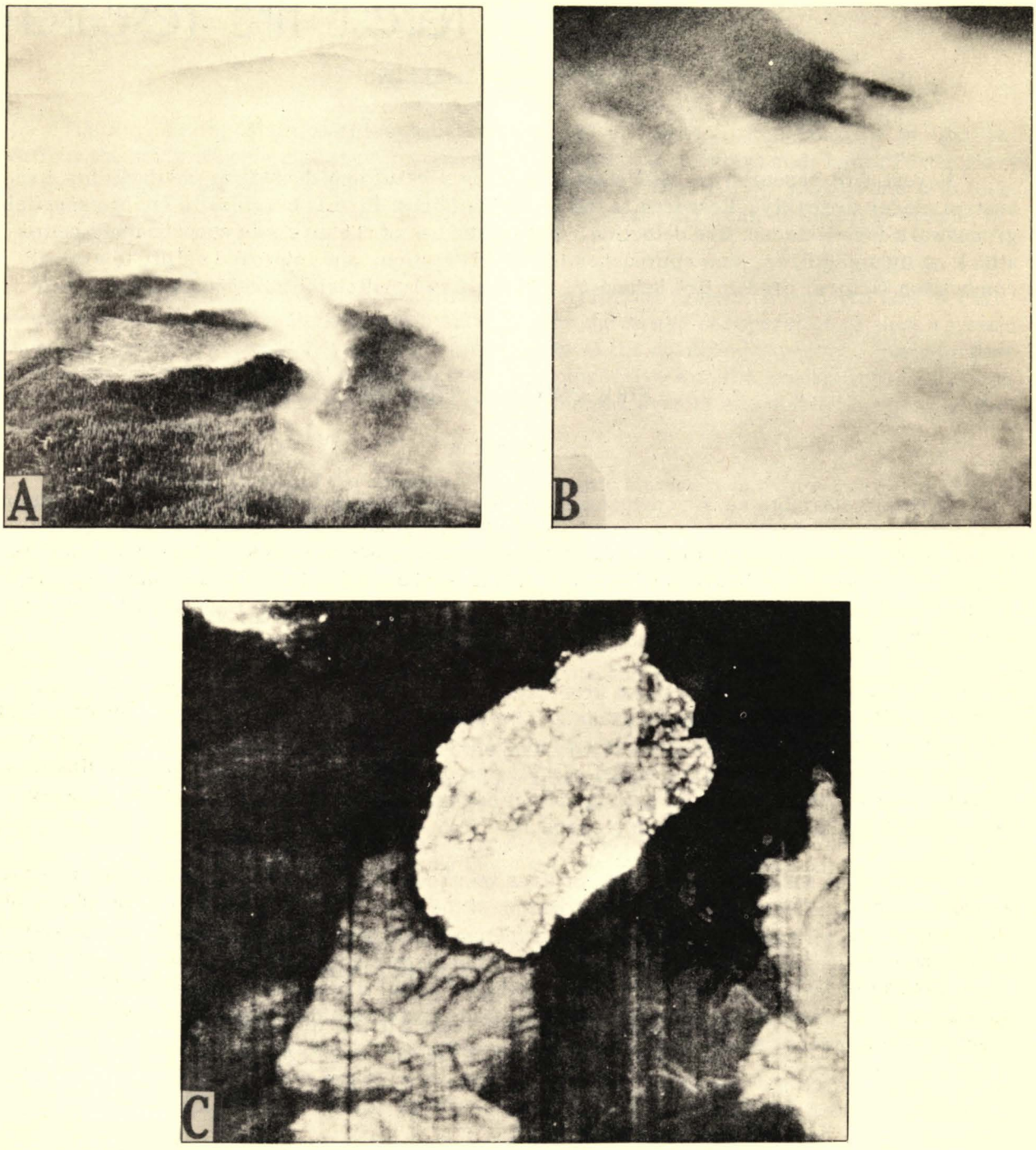


Figure 7.--Aerial views of Kelley Creek fire: A, Approach to the fire; B, from directly over fire area, eye can distinguish little detail; C, infrared image of fire indicates area precisely.

Northern Forest Fire Laboratory completed a series of exacting screening tests under controlled conditions on seven of these chemicals and published the results on them this year.[3] This work marked a milestone in chemical fire retardant research. For the first time it was possible to perform experiments on fire retardants in a combustion laboratory and wind tunnel (fig. 8) where important environmental and fuel factors could be regulated and varied.

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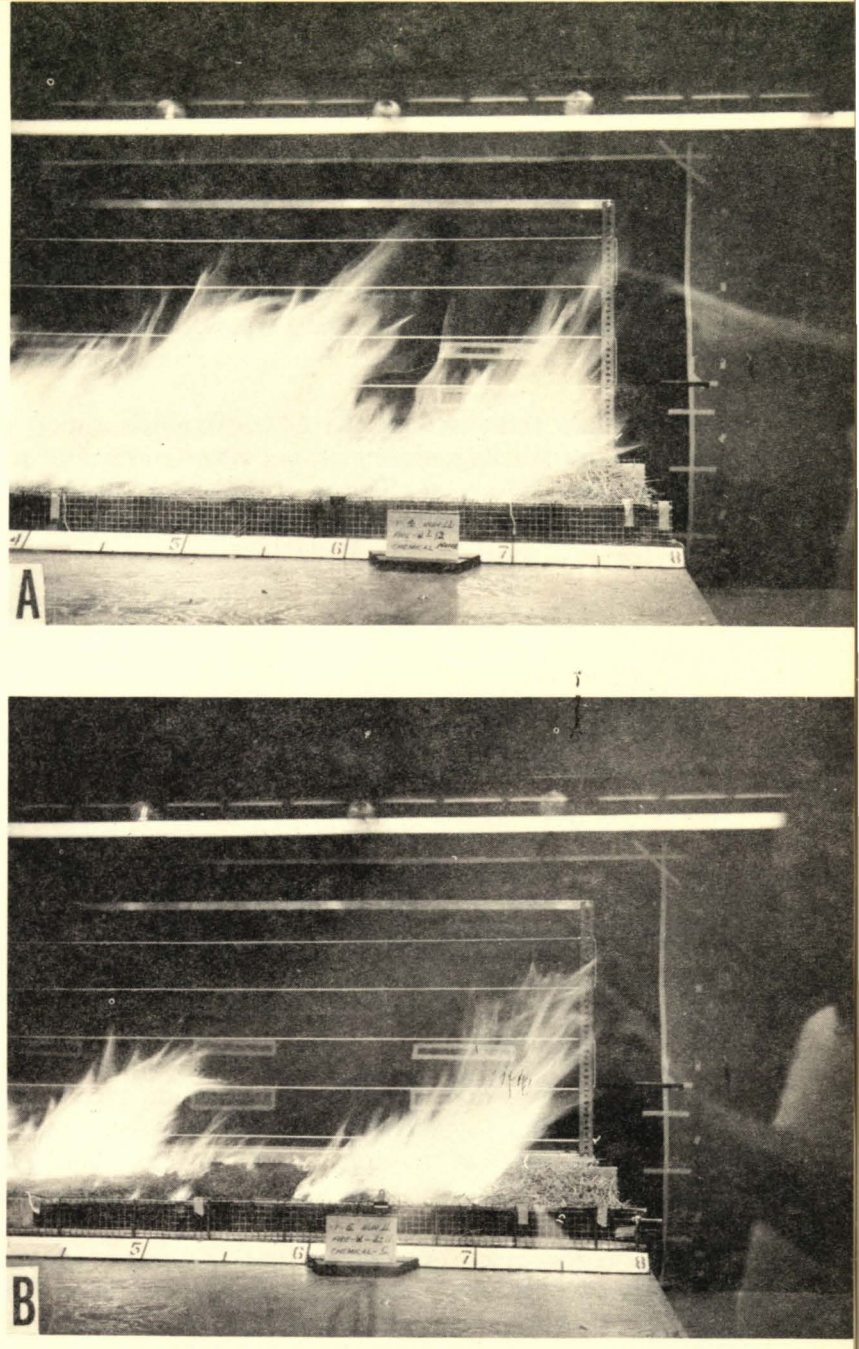
[3] The Pacific Southwest Forest and Range Experiment Station screened these chemicals for use in the Northern Forest Fire Laboratory tests; algin-diammonium phosphate, pectin-diammonium phosphate, ammonium sulphate-attapulgite clay, two sodium calcium borate products, and algin-calcium chloride.



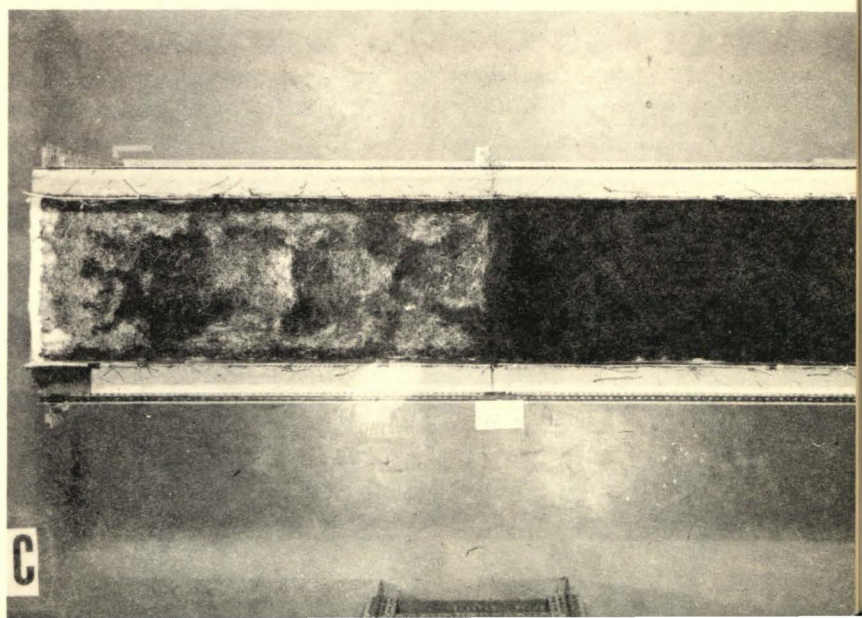




Figure 8.--Testing fire retardant chemicals in fuel beds in wind tunnel: A, Flames burn freely in untreated bed of fuel; B, flames in retardant-treated section are less intense; C, only ash remains in untreated needles on left. Fire burned through but did not consume the diammonium phosphate-treated needles at right (black area).

## Beneficial Use of Fire

In managing certain natural resources, properly controlled fire can be used beneficially to reduce fuel hazards, prepare seedbeds, kill pathogens and insects, open cones to release seeds, and remove unwanted vegetation. Achieving these objectives requires detailed knowledge of fire characteristics and effects--particularly about flame temperatures, convection column phenomena, and heat penetration into forest organisms and soil.

In 1962 this division started new studies aimed at developing information and techniques needed for extending and improving beneficial use of fire. One project, in cooperation with the Engineering Experiment Station of University of Idaho, is investigating possibilities of using a LASER for remote firing from either ground-based or helicopter platforms.

# PROJECT SKYFIRE

Importance of the research on lightning-caused fires was emphasized again by fire season statistics. During the 1960 through 1962 fire seasons, some 30,000 forest fires were started by lightning in the Western States. Project Skyfire continued studies in all its major projects and developed significant information from them.

A belt of intense lightning activity that crosses the Intermountain West can be accurately charted. From southeastern Washington and eastern Oregon it runs eastward through the Wallowa-Whitman, Boise, Payette, Clearwater, Nezperce, and Salmon National Forests; then northeastward through the Bitterroot, Deerlodge, Lolo, Helena, and Flathead National Forests.

## Lightning Storm Characteristics

Analyses of lightning storm data gathered by a network of 38 observing stations over a five-state area and a specially instrumented area in the Deerlodge National Forest yielded considerable usefully descriptive information about characteristics of mountain thunderstorms. The typical summer storm is relatively small, has a high cloud base (average 12,000 or more feet above m.s.l.), with average cloud base temperature of 0° C.

Frequency of lightning storm occurrence in Intermountain territory has varied from 17 to 44 days per National Forest per fire season. Most lightning storm periods are relatively short; about half of these periods lasted from 30 to 90 minutes. About half of all summer storms produce only 10 or fewer cloud-to-ground discharges, but 5 percent of fire-season storms are intense enough to produce 100 or more such discharges.

Many lightning storms are relatively dry. During a 4-year period about half the recorded storms produced less than 0.1 inch of precipitation and an additional 20 percent produced only 0.1 to 0.2 inch. About one-fifth of all these storms yielded hail or graupel.

## Lightning Discharge Characteristics

The area in the Deerlodge National Forest instrumented for measuring and analyzing lightning discharges provided data from 30 storms this season. From a total of some 5,300 discharges, about 2,000 were cloud-to-ground; the remainder were intracloud. Intense storm periods in three storms had peak lightning frequency of more than 40 discharges per 5-minute period; each storm had one or more peaks lasting 30 to 60 minutes. Moderate storm periods

in 12 other storms had generally continuous lightning activity; peak frequency was fewer than 40 discharges per 5-minute period. Marginal records in 15 other storms had only intermittent lightning activity, in which distribution of intracloud and cloud-to-ground discharges were random. Observed radar echo heights ranged between 21,000 and 43,000 feet above m.s.l. The total number of lightning discharges from a storm increases as the maximum height of radar echo increases. These results are useful in evaluating and predicting intensities of lightning storms over western forests.

A study of lightning damage to trees showed that the extent of structural damage was related to tree size. The amount of wood or bark removed by lightning increased as tree size increased. Damage to standing trees was either loss of bark or loss of both bark and wood; loss of both bark and wood occurred only on large trees.

## Weather Modification

Besides continuing scheduled experiments with cloud seeding, the weather modification project developed and tested fast-response instruments and recording equipment for measuring additional details of lightning discharges. Project personnel participated in an international symposium on characteristics of silver iodide and its use in weather modification.

One important activity was participation in studies of cumulus clouds (Project Baton) conducted near Flagstaff, Arizona, by the U.S. Army Signal Corps in cooperation with the U.S. Air Force, the Cambridge Research Laboratory, and Meteorology Research, Incorporated. Cumulus buildups were seeded at cloud bases, and numerous phenomena related to seeding effects were measured at varying altitudes.

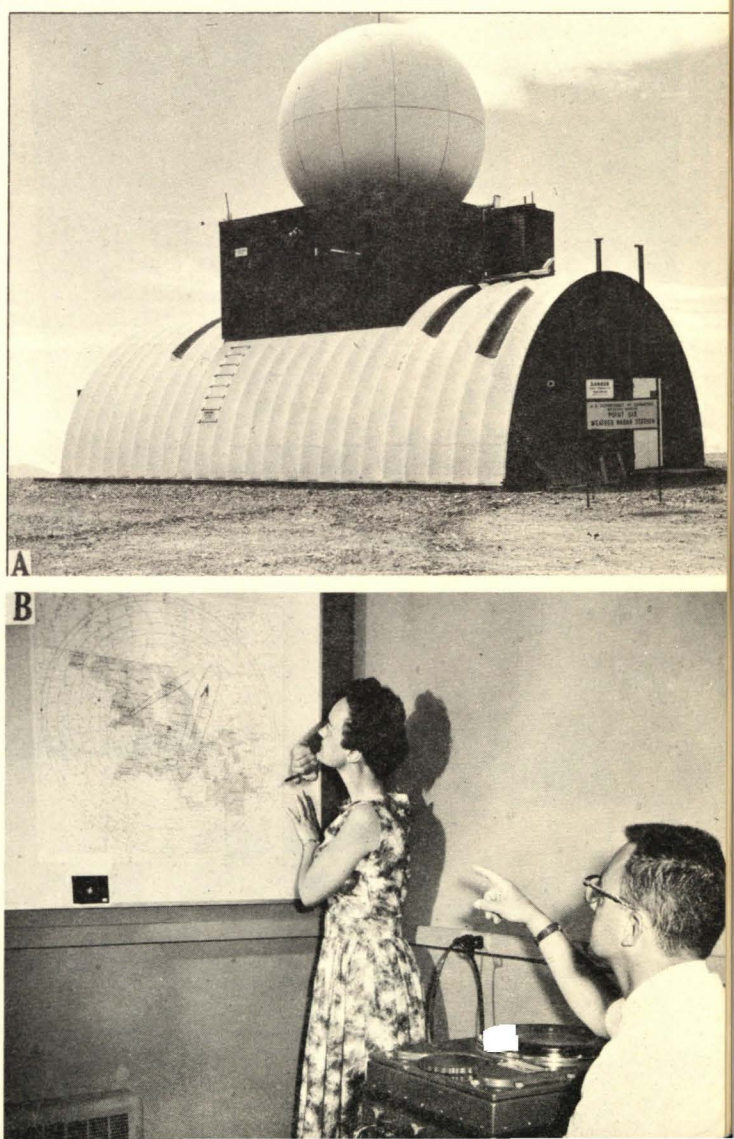



Figure 9.--Weather data received by radar: A, U.S. Weather Bureau radar installation on Point 6 Mountain, 10 miles north of Missoula; B, plotting weather data from the Fire Laboratory's weather radar monitoring unit.

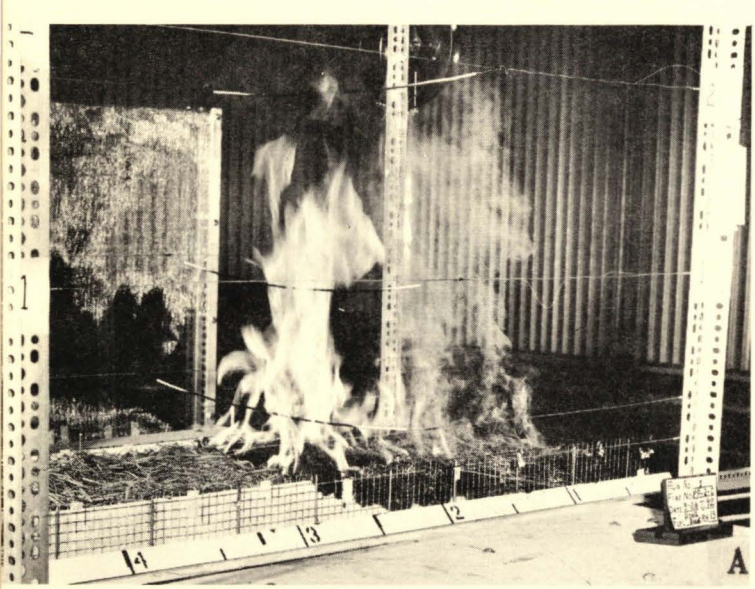
## FIRE PHYSICS

### Mechanisms of Fire Spread

This year's studies of the mechanisms of fire spread[4] centered on the influence of moisture content upon rate of spread and comparison of fire characteristics in ponderosa pine and western white pine fuel beds. Results of more than 30 test fires in the combustion laboratory (fig. 10), with fuel beds containing moisture from 5 to 15 percent, showed that rate of fire spread has a linear relation to this range of moisture. Rate of fire spread in these two fuel types is similar over this range of moisture content, but other measures of fire intensity showed major differences between these fuels. These differences are believed to result chiefly from differences in physical and chemical properties and the optimum loading factor for each fuel.

### Field Studies

Field studies of rate of fire spread, temperature distribution, and convective column were conducted jointly by the Fire Behavior and Fire Physics sections at Priest River Experimental Forest. Results of test fires indicated that: rate of spread increases with fuel loading, but loading effect is much smaller than wind effect; rate of spread probably increases in a logarithmic relation to air velocity; and temperature distribution in the flame and convection column are similar to profiles obtained in the laboratory in relation to flame height. Convection column velocities greater than 20 miles per hour were measured. These experiments show that prepared plots and prescribed burns can be instrumented for measuring temperature and pressure.



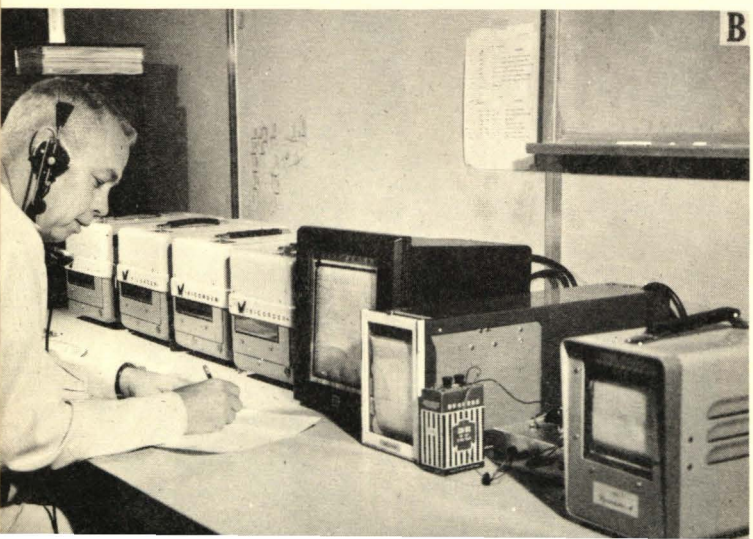




Figure 10.--A, Model fire used to study characteristics and rate of spread in ponderosa pine needles. B, instrumentation readout equipment used in rate of spread studies to determine flame temperatures, rate of spread, radiant energy, convection column velocities and temperatures, and ambient environmental conditions.

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[4] In cooperation with National Science Foundation and Washington State University.

## Fire Aerodynamics

Work continues on the development of wind tunnel research facilities and techniques at the Forest Fire Laboratory. As a result, new experiments on fire propagation, intensity, and spread are now possible. Studies of convection column velocities during both field and laboratory experiments show a close correlation between wind velocity and temperature at the point of maximum flame height.

# FIRE BEHAVIOR

## Fuel Studies

Fuel studies started this year were directed toward determining chemical composition of forest fuels and relating chemical constituents to fire behavior. Initial studies measured ash content, ether extractables, alcohol-benzene extractables, crude fiber, protein, lignin, and moisture in needles of ponderosa and western white pine and in sphagnum moss.

Analyses thus far show chemical composition of the two kinds of needles to be essentially the same. However, when exposed to the same weather environment, ponderosa pine needles level off at a lower equilibrium moisture content than needles of white pine, and have almost twice the amount of ether extractables. This difference in volatile constituents may prove to be a significant fuel factor.

Sphagnum moss, an important fuel over large areas in Alaska, has only about half as much ether extractables as needles of western white pine, but its equilibrium moisture content is higher than that for either type of needles tested.

On the groundwork laid by these initial studies, we are proceeding to analyze calorific values, ignition characteristics, and physical and chemical properties of five coniferous species. Fuel flammability differences will be investigated according to variations in age, elevation, and other site factors.

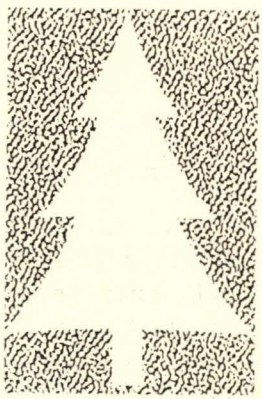
## Fire-Danger Rating

Research in fire-danger rating this year was centered on development of a unified system. The proposed rate of spread index (Phase I) for the system has been checked, and results show correlation between the proposed national system and the existing Intermountain fire-danger rating system. With local refinement, Phase I can be adopted for use by fire control agencies. This local adaptation will include necessary corrections for effects of altitude and aspect for various times of day; and these must be related to local fuel types on the full range of slope from level to near perpendicular.

Research is continuing on development of a system to rate the severity of each fire season. In 1962 we completed work on a fuel moisture scale shelter; we are now designing and trying a prefabricated anemometer mast and an automatic fire-danger rating station.

## Prediction and Evaluation of Fire Behavior

A major effort was the design, preparation, and execution of the fire spread experiments reported above. Fuel beds and instrumentation were designed after experiments with outdoor wood cribs and slash beds at the Fire Laboratory. Rate of forward spread, flame depth, and flame height were measured from a projection of movies. In addition to the results reported above, these experiments led to a conclusion that a long plot fired at one end performs better than a circular or square center-fired plot for studying rate of spread. Indraft to a center-fired plot appears to produce a lower rate of spread than a free-burning front.



# forest insect research

Realignment of the forest insect research program under three line projects was effected in 1962. These projects describe active and proposed studies of bark beetles, defoliators, insects affecting regeneration, and those affecting range browse plants. Two new studies were started during the year; one on the population dynamics of mountain pine beetle in western white and ponderosa pine in the Northern Rocky Mountain Region, and a second of insects affecting regeneration in the same region.

## MOUNTAIN PINE BEETLE IN LODGEPOLE PINE

Intraspecific competition within mountain pine beetle broods in lodgepole pine was studied at different attack densities, under laboratory conditions. The two proposed objectives were: (1) to determine what effect interference between broods at different attack densities would have on production of adults, and (2) to perfect laboratory rearing techniques so that relatively stable populations can be produced in test logs for use in evaluating effects of parasitism and predation under controlled conditions.

Individual log sections were partitioned into three sectors by mechanical barriers that prevented migration of larvae from one sector to another. Confining beetle pairs to the immediate area of a hole drilled to the xylem resulted in distributing attack points to allow the maximum space for brood development at each attack density without interference from neighboring broods. Each log had one sector at each of three attack densities: 3, 9, and 18 per square foot, within three log replicates.

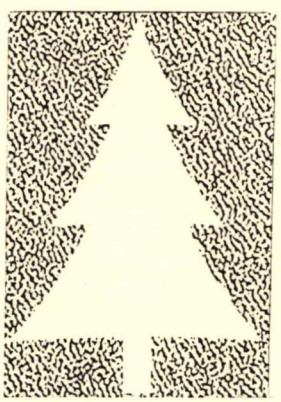
Analysis of results from this study revealed that interference did occur; it increased with attack density, and resulted in lowered production of new adults per parent female. Mortality from egg to adult increased in direct proportion to attack density from three to eighteen per square foot at levels of 86, 90, and 94 percent. This mortality during larval development was higher than had been expected; additional studies are being planned to determine the nature of these losses. The spread between attack densities used was quite broad, and maximum production of new adults per female parent may lie between three and nine attacks per square foot. Additional tests are planned to determine the most productive attack density before competition between broods becomes a significant factor.

Rearing techniques developed during this study will be satisfactory for use in planned studies of parasitism and predation.

## LARCH CASEBEARER

The larch casebearer, Coleophora laricella (Hbn.), since its discovery in Idaho in 1957, has continued to spread and seriously defoliate western larch. Visible defoliation covered 1,440 square miles in northern Idaho in 1962 compared with 700 square miles in 1961.

Agathis pumila (Ratz.), a small Braconid wasp obtained from eastern infestations of the casebearer, was liberated in Idaho in 1960. We reared no adults of this parasite from extensive collections of casebearer in 1961, but did recover it from one of five liberation sites in 1962. This result is significant, for it means that the parasite became established in 1960 and completed two generations in this new environment. Collections for several years have revealed no significant native parasites. Establishment of Agathis furnishes an unusual opportunity to evaluate the effectiveness of one species of parasite in reducing populations of casebearer. This facet of the casebearer problem is now being studied.



# forest utilization research

The purpose of Forest Utilization Research is to evaluate and analyze problems of the forest industries; to mold and shape research programs at the Forest Products Laboratory and elsewhere to find answers to these problems; and, finally, to get research results into early and general application. Our 1962 research effort made substantial contributions in all three activities.

Forest-based industries in the Intermountain area are plagued by many fundamental problems in raw material procurement, production and processing technology, and marketing. These problems are not unique to this area, but are in many ways greatly aggravated here. Available timber is often remotely situated, poor in quality, small in size; many processing plants need major modernization; often, there is a lack of facilities for full utilization of the tree, particularly the fiber and chemical portions; and the many small mills find it hard to market their product.

New uses are constantly being discovered for wood and wood-based products, new adhesives, new paints, new byproducts, and a whole host of new goods that demonstrate this changing utilization technology. Similarly, the raw material base has shifted from large, high quality trees of preferred species to a more heterogeneous mixture that includes previously little used species and small sizes. The old-fashioned single-product sawmill has diversified both its raw material input and its product output. On the other hand, some specialized mills have drawn on only a restricted part of the available raw material to produce highly specialized products: the stud mill is an excellent example.

By and large, the forest industries are attempting to gear themselves to "market oriented" products--items they either know or hope the consumer wants.

This changing situation didn't just happen; it grew out of continued analysis, a timely research effort, and the early application of research results.

As a part of this greater effort--one shared by the Forest Products Laboratory, the colleges and universities, other research agencies, and, of course, the industry itself--Intermountain Station has been instrumental in providing a certain catalytic impulse. The Station has distributed more than 5,000 technical publications this year dealing with various aspects of wood utilization. Station personnel have met with numerous Rural Area Development, Area Redevelopment, or Industrial Development committees advising them on industrial potentials and opportunities.

Station personnel have actively participated in programs of technical and professional societies, and have otherwise capitalized on opportunities to acquaint builders, manufacturers, and wood processors with research progress and results. We have sponsored cooperative research programs at universities and have helped in molding research programs.

In all of this our contribution has been substantial, and the results are paying off in newly created industries such as new plywood mills, wood chemical plants, laminating facilities, better dried lumber, and more market oriented production.

We have attempted to add to the fundamental knowledge of wood--the knowledge from which all applied research must stem. We have participated in the National Log Grade program for both the ponderosa pine and Douglas-fir working groups. New log grades for ponderosa pine lumber logs have been developed as a result of this effort, grades that give more reliable results than grading systems heretofore used. Data have been collected for development of Douglas-fir and Engelmann spruce log grades. As a phase of these studies, spiral grain determinations are being made for each butt log--a wholly new approach to correlating tree quality with inherent tree properties. Further, we have collected tree specific gravity data in support of the Western Wood Density Survey.

Progress was made towards completing analysis of the properties and behavior of spiral grained poles. Among other things, this study has shown that poles with right-hand twist more nearly approach normal or average strength values than do left-hand spiral poles, and that the slope of grain along the length of a pole varies within any given growth ring.

Our study of the durability of fenceposts and pole lines, that had been installed years ago, was completed and the results have been published.

# range management and wildlife habitat research

Reorganization during the past 2 years has oriented this division's program into four major projects of range management research and three of wildlife habitat research, as follows:

Management of cheatgrass and sagebrush-grass ranges of the Snake River Plains and of adjacent mountainous ranges with granitic soils (Boise, Idaho).

Rehabilitation and management of livestock and elk ranges on northern Rocky Mountain grasslands (Bozeman, Montana).

Management, ecology, and physiology of salt-desert shrub, sagebrush-grass, and pinyon-juniper rangelands of the Great Basin and the Colorado River drainages of eastern Utah and southwestern Wyoming (Provo, Utah).

Management of mountain herbland, brushland, and aspen ranges (Provo, Utah; later Logan, Utah).

Rehabilitation and management of deer winter range (Boise, Idaho).

Management of wildlife habitat and integration of game and timber production in forest types of northern Idaho and western Montana (Missoula, Montana).

Restoration and management of critical big-game range, and wildlife-livestock relations on Intermountain wildlands (Provo, Utah).

## CHEATGRASS AND SAGEBRUSH-GRASS RANGES

Sagebrush-grass ranges cover approximately 40 million acres of the Snake River Plains and adjacent areas in southern Idaho and eastern Oregon and Washington on soils derived from igneous and related sedimentary materials--including extensive aeolian deposits. These ranges are particularly important for spring and fall grazing and are potentially highly productive--as shown by long continued research conducted in cooperation with the U.S. Sheep Experiment Station at Dubois, Idaho. With rotational grazing they sustain 40 to 60 sheep-days of grazing per acre per year. Appropriate grazing management can maintain a desirable balance between shrubs and herbaceous species. Results show that spring grazing with sheep favors the shrubs; fall grazing, the grass and forbs. Brush also can be reduced and perennial forbs and grasses increased effectively by planned burning if accompanied by proper grazing management.

Haphazard grazing and fire have converted much of this range to dense sagebrush or almost pure cheatgrass. Cheatgrass, an aggressive annual, becomes prominent on deteriorated range and takes over in the absence of herbaceous perennials when such brush is burned; then it greatly increases the fire hazard by producing a continuous cover of flash fuel. Thus, it has continued to spread and now dominates an estimated 4 to 6 million acres in southern Idaho and about 10 million acres in Oregon. Because cheatgrass has both desirable and undesirable characteristics, it is both praised and cursed by stockmen and land managers. Little is known of its actual value or how it should be managed for best results.

In cooperation with the Bureau of Land Management at Saylor Creek Experimental Range near Glenns Ferry, Idaho, we are studying grazing values of cheatgrass range for cattle and sheep, and its response to grazing at different times of the year. This, along with ecological information, should tell us how to design grazing systems that will use available forage effectively and also encourage desirable species. Studies concerned with optimum management of good condition ranges without cheatgrass are continuing on a limited scale at the U.S. Sheep Experiment Station.

## NORTHERN ROCKY MOUNTAIN GRASSLANDS

The range livestock and great elk herds of the northern Rocky Mountain region are nationally renowned. Picturesque mountain grasslands with intermixed forests have economic and aesthetic values that are highly esteemed in Montana and adjacent states. Most of these ranges appear to be in better condition than mountain grazing lands of other Western States. However, even Montana has serious range problems that should not be ignored merely because they are less advanced than elsewhere. Damage by grazing of livestock or big game varies from only minor replacement of the best forage plants with inferior ones at the one end of the scale to greatly reduced plant cover and accelerated soil erosion at the other. The worse deterioration has occurred in three situations: (1) high-elevation herblands grazed by sheep and game during a short midsummer growing season; (2) elk ranges used by great herds of the Yellowstone-Teton area; and (3) foothill and valley range used by livestock in spring and fall and big game in winter. The more extensive cattle ranges at medium elevations seem to be in relatively good condition but are producing less than their potential; some appear to be deteriorating.

Actually, little specific knowledge of the basic nature of these rangelands is available to guide effective management. Therefore, the initial phase of our research is seeking the ecological and physiological background needed to determine range condition in relation to potentials, to detect improvement or deterioration, and to develop grazing practices that will better satisfy the growth requirements of specific types of vegetation. Ecological studies are in progress on the high quality, midelevation fescue grasslands, and on grass-forb ranges at high elevation. Effects of defoliation at various stages of growth on several forage species, and factors influencing distribution of cattle on mountainous topography, are being studied as background for developing improved grazing practices.

## DESERT SHRUB, SAGEBRUSH-GRASS, AND PINYON-JUNIPER RANGES

These three range types characterize the low-elevation rangelands of the Great Basin and the Colorado River drainages that occupy most of Nevada, Utah, and western Wyoming. Their management problems have much in common. In this semiarid climate, their primary value is for livestock grazing and wildlife. Since all have a similar history of destructive use and deterioration, all range research applicable to them has been organized into a single broad project located at Provo.

This Station's research on desert shrub ranges began in 1933 with establishment of the Desert Experimental Range. After 30 years of carefully managed grazing by sheep, this range exhibits convincing evidence of the great opportunity for increasing nutritious browse and controlling undesirable species, such as the poisonous halogeton, through grazing management alone. At the same time, stockmen's net income per sheep on this range has been double that on overgrazed outside range because of higher animal productivity and lower expenditures for supplemental feed.

On sagebrush-grass ranges, the feasibility of quickly restoring herbage production by killing brush and seeding adapted grasses was established by early research in the 1940's. More recently, we have been studying management of crested and fairway wheatgrasses. The intensity of spring grazing compatible with sustained productivity of these species has been established through comprehenisve studies at the Benmore Experimental Area. Utilizing more than 60 percent of the herbage not only decreased forage production but also encouraged sagebrush reinvasion; this greatly shortened the effective life of the seeding. But even with light grazing or none at all, significant amounts of sagebrush invaded good grass stands in 2 out of 10 years when spring and summer moisture was especially favorable. Since this suggests that positive management may be necessary to control sagebrush in the Great Basin climate, we are investigating possibilities of applying sheep grazing specifically for this purpose.

Further investigation of the brush problem has revealed marked contrast in the effects of rubber rabbitbrush and big sagebrush on range productivity. This difference is not recognized in most of the literature. Grass yields were little affected by rabbitbrush (increased near stems) but suppressed by sagebrush in a zone that widened as plant size increased (fig. 11). The effect was so prominent that it appeared as a "halo" on good aerial photos and thus provided a means of distinguishing big sagebrush from rubber rabbitbrush in photo interpretation. The root systems and growth periods of these two species explained the contrasting effects. This matter is pertinent to decisions regarding brush control operations, especially the timing of herbicide spraying since the period of maximum susceptibility is different for the two species.

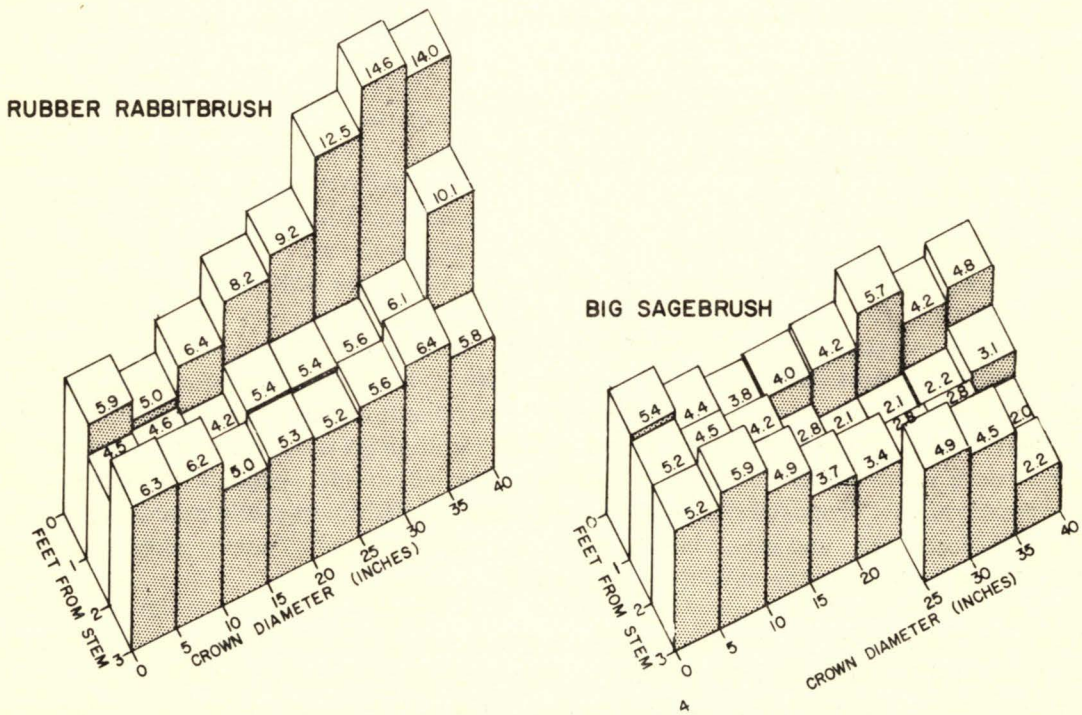



Figure 11.--Herbage yields (grams per square foot, air dry) of crested wheatgrass in concentric 1-foot plots around individual sagebrush and rabbitbrush plants of different sizes. The 3- to 4-foot zone was sampled only for sagebrush having crown diameters more than 25 inches. The total samples included 120 plants of each species, 10 to 20 per diameter at Benmore Experimental Area.

## MOUNTAIN HERBLAND, BRUSHLAND, AND ASPEN RANGES

These range types dominate mountainous portions of Utah, Nevada, and southern Idaho and provide summer grazing for about 1-1/3 million sheep, 1/3 million cattle, and perhaps 3/4 million deer and elk. Also, these mountainous areas have important scenic and recreational values and are the primary source of the region's water. Since all these resources are in short supply, making livestock grazing compatible with other uses and values is part of a complex management problem. A century of grazing has changed these range types even more drastically than most others in these Intermountain States because their productivity initially was so much higher. But, from an optimistic viewpoint, possibilities for improvement should be correspondingly great except where soil losses have too nearly destroyed the productive potential.

Research on mountain herbland, brushland, and aspen ranges began about 1911 with the pioneering work of A. W. Sampson and associates. Results of most of the early studies reflected the severe deterioration of the range and soil resources that had been progressing for years, and thus tended to spotlight abusive grazing--a sore subject in this region.

New grazing research was started in 1959 in cooperation with National Forests, and in 1960 a small project was started in cooperation with Utah State University. These latest studies emphasize improved grazing management. This had received relatively little direct attention in the past research--mostly conducted either on open range or protected areas. We want to learn how to improve distribution of grazing on mountainous terrain so as to utilize the forage effectively while maintaining high productivity and preserving soil stability. Several systems of grazing cattle and sheep are being investigated on different types of vegetation, topography, and soils.

## REHABILITATION OF DEER WINTER RANGE IN SOUTHERN IDAHO

As elsewhere, big-game hunting in southern Idaho is rapidly increasing in popularity. More than 120,000 hunters are reported to have killed about 75,000 deer in Idaho in 1960--a threefold increase over the estimated kill in 1950. Three-fourths of these deer were in the southern half of the State. The upward trend in hunting demand is expected to continue. At the same time, deer herds in southern Idaho face a shrinking habitat, especially in their limited, critical winter range. Proposed dams and reservoirs, expanding highway systems, agricultural and urban developments, and other human activities will continue to usurp some key areas and influence others by interfering with deer migration.

However, the most important problems of deer winter range are related to fire and to overuse of desirable food plants by excessive game populations and livestock. The combined effect of these factors already has depleted much of the winter range to the extent that artificial reestablishment of desirable vegetation appears necessary to restore useful habitat. A reasonable degree of control over game populations now appears feasible, but not enough is known about the tolerances and requirements of the vegetation to guide effective management. Since much of the deer winter range is also livestock summer range, integrating the two kinds of use is part of the problem to be solved.

Limited research directed at revegetating depleted winter ranges on loose, granitic soils near Boise has been in progress for a dozen years in cooperation with the State of Idaho Department of Fish and Game. Following an initial screening of potential browse species, study has been concentrated primarily on bitterbrush. Although procedures have been developed for seeding this species with reasonable success, chances of failure are great enough to warrant further effort in identifying and overcoming the factors responsible.

Other facets of current investigation include: a more efficient technique for measuring browse production and utilization; insects that influence natural reproduction of bitterbrush; and evaluation of site potentials for bitterbrush production.

## MANAGEMENT OF WILDLIFE HABITAT IN NORTHERN IDAHO AND WESTERN MONTANA

The extent of wildlife resources of the 26 million acres of commercial forest lands of northern Idaho, eastern Washington, and Montana west of the Continental Divide--the "Inland Empire"--is indicated by the sale of more than 300,000 fishing and hunting licenses and an estimated annual harvest of nearly 150,000 elk and deer. Maintaining the big-game resource, however, presents distinct problems of habitat management related to the dense canopy characteristic of the common forest types: western white pine, hemlock, Douglas-fir, larch, and associated species. Deer and elk depend for food upon shrubs and herbaceous species that do not persist under dense tree canopies. Consequently, management of the wildlife habitat involves manipulation of both the tree cover and the understory vegetation in maintaining food plants in adequate supply.

Following the extensive forest fires of 1910-1919, favorable habitat and large game populations developed. In recent years, volume of available browse has declined continuously as a result of suppression by reestablished timber stands, height growth beyond game reach, and overbrowsing by both game and livestock. Future big-game herds will depend primarily upon browse maintained through timber harvest, and upon supplemental winter range provided through intensive management of limited snow-free sites specifically for game. Just how this can be accomplished is a problem for which our project at Missoula seeks solution.

Ecology of the transitory browse communities is being studied as an initial approach to the understanding of management possibilities. Two years ago we reported[5] initial results from the cedar-hemlock (white pine) zone, indicating influences of such factors as logging and burning disturbance and amount of tree overstory, on the kinds and amounts of shrubs in the understory. Effects of different silvicultural practices on shrub development also are being investigated.

An initial study in the Douglas-fir zone, started this year, emphasizes the time sequence of successional changes in the understory vegetation following fires. Thus, we are starting to accumulate information applicable for integrating wildlife habitat into forest management. Many aspects of this problem are yet untouched, including the question of the degree of game use compatible with timber stand regeneration.

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[5] Intermountain Station Annual Report, 1960, p. 33.

Possibilities for immediate improvement of big-game habitat in this region appear to be best on the old burns where extensive brushfields have grown beyond animal reach. Scouler willow, serviceberry, and bitter cherry are some important species. Some practical means is needed for killing back the tall crowns and stimulating basal sprouts to restore effective browse production.

Aerial application of herbicides is a logical possibility. Preliminary tests showed that the most common herbicides, 2, 4-D and 2, 4, 5-T, are reasonably effective for killing tall crowns when applied at the rate of 3 to 4 pounds (acid equivalent) per acre. However, optimum time for application varies somewhat among these species, and other highly desirable species such as redstem ceanothus (sometimes occurring with them) may be severely damaged at certain times. No doubt better chemicals for this purpose can be found.

As a means of encouraging collection of information on browse species and their utilization by wildlife, particularly on winter game range, an illustrated key for use by field men in identifying shrubs in the dormant, winter condition, was published this year in cooperation with Montana State University.

## WILDLIFE-LIVESTOCK RELATIONS AND HABITAT RESTORATION

Harmonious integration of wildlife with livestock grazing and other wildland uses is becoming increasingly important throughout the Intermountain Region. Problems are widespread and varied. They involve the habitat not only of big game but also of sage grouse and other upland game birds, and of trout and other game fish. Some progress has been made toward restoration and integrated use of big-game habitat, but practically no research yet has been concerned with other wildlife habitat in relation to grazing or other wildland uses.

Much of this Station's research to date on big-game habitat in Utah has been conducted in cooperation with the Utah State Fish and Game Department and the U.S. Fish and Wildlife Service in Utah. The problems here, however, extend to adjacent states. It is estimated that deer use more than 20 million acres of this State and provide hunting for more than 175,000 hunters annually--a number that has doubled in 15 years. Big-game numbers peaked about 20 years ago and have remained high on range already fully grazed by livestock and in deteriorated condition. Approximately 80 percent is public range managed under a multiple-use concept. Demands for forage exceed the supply; so land managers face problems of allocation and integration of use as well as the difficulties of increasing and maintaining overall productivity. Livestock and wildlife interests often have conflicting viewpoints on such questions as relative use of forage by livestock and big game, responsibility for overuse and range deterioration, and effects on wildlife of such practices as brush control and range seeding to increase livestock forage. Available information is far from adequate to resolve such problems of multiple use satisfactorily.

Procedures for restoring productivity on depleted winter range for deer, primarily in the pinyon-juniper zone, have been studied since 1955 in cooperation with the Utah State Fish and Game Department. This zone includes most of the critical winter deer range of the Utah-Nevada area, and presents special problems related to past history and characteristics of pinyon and juniper. Unregulated livestock grazing many years ago weakened or killed much of the herbaceous vegetation and encouraged species unpalatable to livestock--including pinyon, juniper, sagebrush, and other shrubs that provide useful cover to deer and emergency food during severe

winters. Subsequently, the desirable browse species also have been almost eliminated by excessive populations of deer from many areas. The remaining juniper and pinyon trees have little food value; and they consume the limited moisture and severely compete with other vegetation; thus they prevent natural recovery and improvement of the habitat (fig. 12).

Initial results and tentative recommendations from our cooperative studies already are guiding extensive restoration activities by several public agencies. Reduction of juniper and pinyon overstory by chaining, dozing, or burning restores production of game forage where enough desirable plants have persisted. Otherwise, seeding also is required. For this purpose, a dozen shrub species, about 10 forbs, and 7 grasses can be recommended in different combinations for various soil and site conditions. Rubber rabbitbrush and big sagebrush, two "weeds" of cattle range, are among the most useful shrubs for rehabilitating critical winter range for deer in the Great Basin area.

Figure 12.--Past overuse by livestock and game has killed most of the understory herbage and browse on this winter range site for deer in southern Utah. Restoring productivity will require removal of tree competition, possibly followed by reseeding of browse and herbaceous species.

Past research on competition between livestock and deer has considerably influenced deer management in this region. Conflicts have been most serious on deer winter range that also is spring-fall or summer range for livestock. In this situation, competition was found to be largely a matter of intensity of use. As a generalization, livestock and deer are likely to eat different kinds of plants when they can be selective; they compete strongly for the same plants only after preferred plants have been utilized heavily.

A current study is investigating summer range of deer and elk to determine the characteristics of habitats preferred by each, and how these habitats are related to range used by livestock.

# watershed management research

Watershed management research made significant progress in 1962. Some new studies were begun; a few old ones were completed and terminated. The following account indicates the direction of some of our research and the progress being made.

## Soil Stability Characteristics of Central Utah Summer Range

Control of soil erosion on rangelands in the Intermountain area is an important element in watershed management. Excessive loss of soil leads to decreased forage productivity, increased flood potential, and impaired water yields. Our past research has developed important relations between plant cover and soil erosion. Our recent studies have sought to define these relations with greater precision, and also to determine the effects of soil properties, slope, and other related site factors on the erodibility of different soils. One of these studies, in which a rainfall simulator was used, was completed on herbaceous summer range in central Utah in 1961. During the summer of 1962, this same type of field work was extended to two other areas: the Davis County Experimental Watershed in northern Utah and the Gravelly Mountains of southwestern Montana.

Results of the central Utah study confirm those of earlier investigations; they show that soil stability is closely correlated with density of protective ground cover. In addition, quantitative relations between soil eroded by a simulated design storm and vegetation characteristics, soil properties, and slope were derived for the study area.

The most significant relations are presented graphically in figure 13. Protective ground cover (understood here as the percent of soil surface protected by plants, litter, and stone) is the single variable most highly correlated with the amount of soil eroded. Furthermore, on these fine-textured soils, the relation between protective ground cover and soil eroded is affected significantly by soil properties, particularly the bulk density of the surface inch of soil. Figure 13 shows that the amount of soil eroded at a given ground-cover density increases as bulk densities increase, particularly at lower ground-cover densities. When ground cover is dense, soil bulk density is less important.

## Free Water Evaporation in Mountainous Terrain

Concern about the adequacy of water supplies to meet future needs focuses attention on determining quantitatively water losses within the hydrologic cycle. Water loss by evaporation is important, yet comparatively little is known of this phenomenon in mountainous terrain. To obtain information about the amount of evaporation from free water surfaces, Intermountain Station established, in cooperation with the U.S. Weather Bureau, a network of 12 evaporation stations on the Davis County Experimental Watershed.

This study seeks to determine variations in amounts of water evaporated under a variety of mountain site conditions. A valley station at Farmington, Utah (elevation 4,334 feet), serves as a control. Extremes in station locations are illustrated in figures 14 and 15.

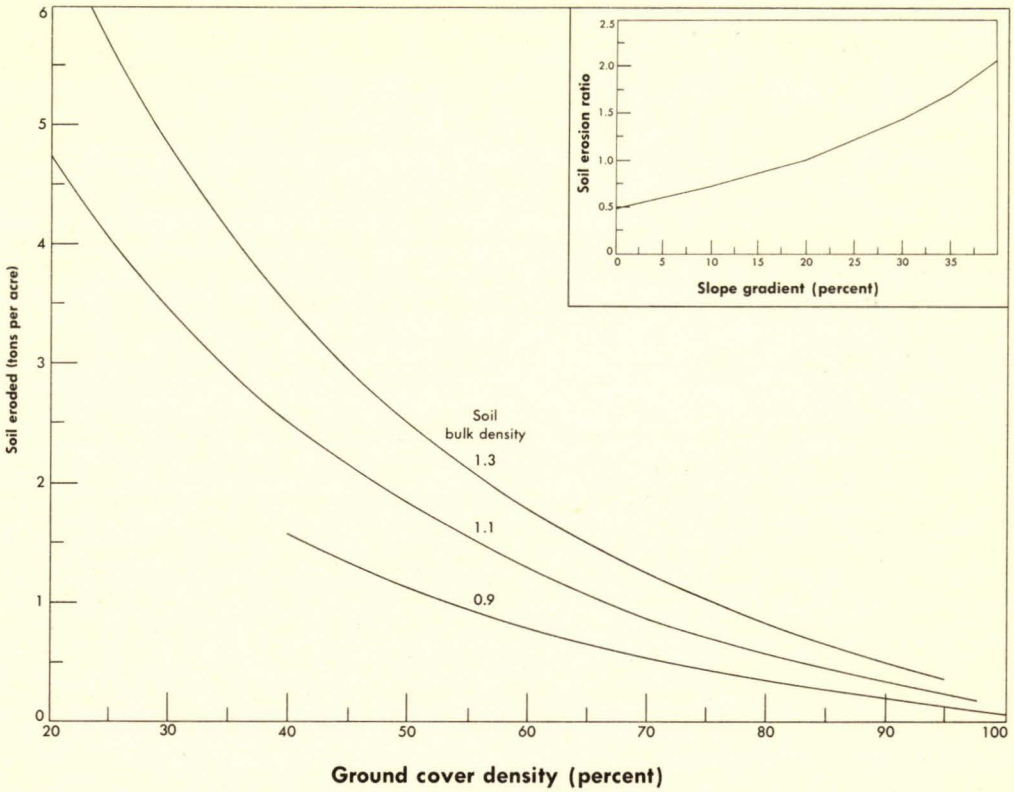


Figure 13.--Soil eroded by 2.5 inches of simulated rainfall during a 30-minute period, as affected by ground cover density and soil bulk density. Insert shows ratio of soil eroded on various slopes to that eroded on a 20-percent slope.

Total losses by evaporation during a 91-day period ranged from 19 to 31 inches. Variations from one station to another are great enough to suggest that evaporation is a highly complex process, which is conditioned by the environment of the site.

## Criteria for Erosion Control on Logging Roads

As the amount of timber harvested from any given area is increased, more logging roads are required. Experience here and elsewhere indicates that too frequently poorly located, constructed, or maintained roads cause the greatest part of watershed damage that results from logging. Timber harvesting in the Northern Rocky Mountain Region in recent years has necessitated building approximately 1,600 miles of truck and jammer roads and 1,000 miles of tractor trails annually. Despite all the precautions that have been used to control soil erosion and sediment movement, a substantial proportion of the sediment that reaches stream channels from forest lands originates on roads.

A study just completed provides comprehensive information that, when used to guide location and construction of forest roads, can materially reduce these damages. We determined which natural characteristics of watersheds and which design characteristics of secondary logging roads dominantly influence erosion and sediment movement from roads located on six major soil groups; namely, those derived from basalt, hard sediments, andesite, granite, glacial silt, and loess.

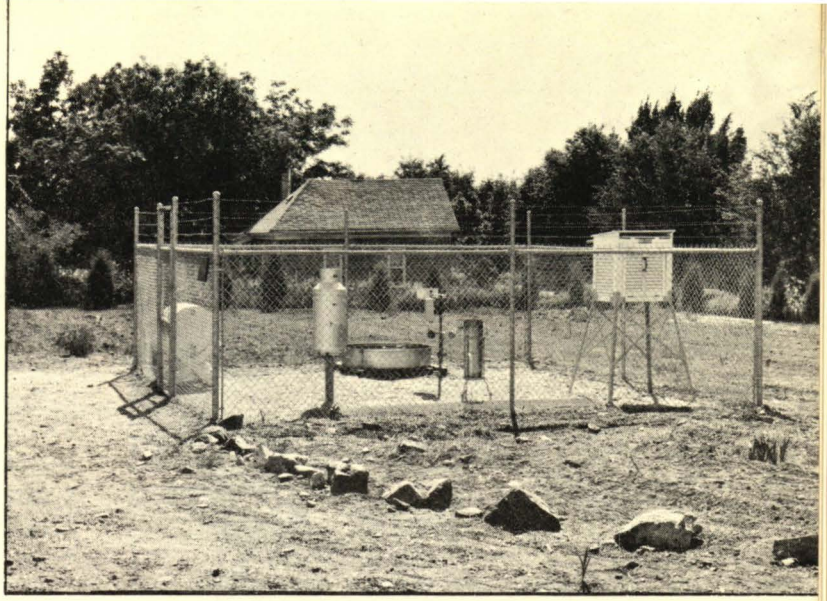

Figure 14.--Evaporation Station 1, Farmington, Utah. Elevation 4,334 feet; mean daily summer evaporation 0.288 inch; mean summer temperature 72° F.; mean wind velocity 24.5 miles per day.

Erosion control criteria to prevent rill or gully erosion on roads are based on spacing of cross drains. The required cross-drain spacings were found to depend upon: (1) two controllable road characteristics--proportion of road surface water-stable soil aggregates larger than 2 mm. in diameter and steepness of road surface gradient, and (2) three unalterable watershed characteristics--topographic position, aspect, and steepness of the slope above the road cut. The most important of these five factors is the proportion of soil aggregates larger than 2 mm.

The distances that sediment moves downslope below outlets of road cross drains were used as a basis for defining the widths of protective strips that are needed below roads to prevent sediment from reaching stream channels and other lower lying developments that require protection. These distances, and the protective-strip widths required for sediment control, were found to depend upon: (1) four manageable watershed characteristics, (2) one unalterable watershed characteristic, (3) one controllable road characteristic, and (4) age of roads expressed as years since construction.

The six soil groups studied, in order of increasing widths of required protective strips are those derived from basalt, andesite, glacial silt, hard sediments, granite, and loess. Closer cross-drain spacings on the roads result in smaller volumes of runoff being discharged from the outlets of these structures and permit use of narrower protective-strip widths.

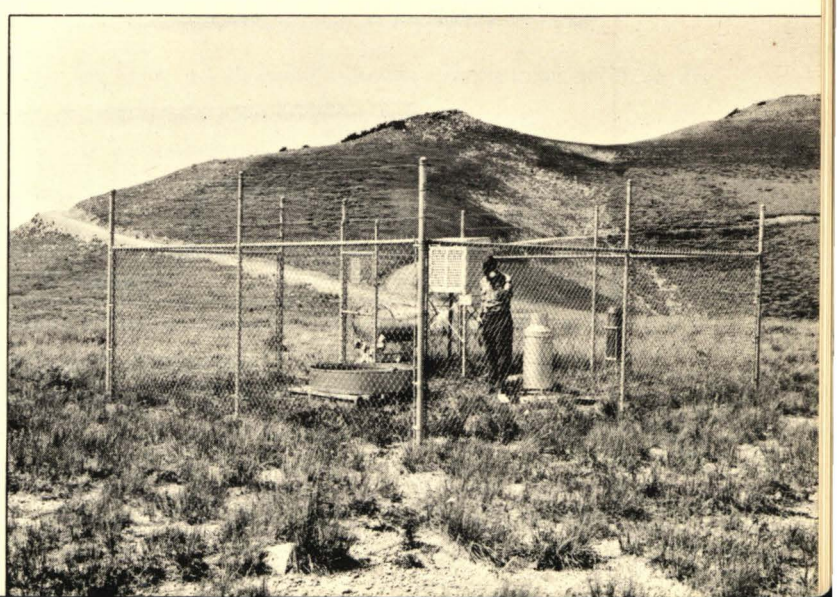

Figure 15.--Evaporation Station 4, Upper Halfway Creek Watershed. Elevation 8,960 feet; mean summer evaporation 0.334 inch per day; mean summer temperature 58° F.; mean summer wind velocity 129.0 miles per day.

Figure 16.--Soil moisture being measured with a neutron probe. Probe and scaler are mounted on two-man carrier, designed by research personnel.

The quantitative relations revealed by this study have been developed into a series of graphs and tables from which protective cross-drain spacings and protective-strip widths can be obtained, provided that information of the watershed and road design characteristics involved is known. These criteria are applicable to two general kinds of logging road problems. The more important is proper location of a logging road before construction to insure that sediment from it does not reach sites needing protection. The other is control of sediment from previously built logging roads.

## Supplementary Equipment Designed for Research

Two equipment developments completed this year may be of interest and value to others conducting soil moisture studies. One was production of a two-man litter-type carrier for a neutron probe and scaler. This carrier reduces the gamma radiation dose for personnel and protects the equipment against jolts (fig. 16). Each man is $3\frac{1}{2}$ feet from the probe while transporting the equipment; this distance reduces the radiation dose per man by about 75 percent. Modifications to the carrier will accommodate any make of neutron moisture-measuring equipment.

We also developed a tool to restore, quickly and accurately, a dented soil moisture access tube to its original diameter while in place in the soil (fig. 17). This tool can also be used to check all access tubes before a probe is inserted to insure that the tube is free of constrictions. Specifications for this tool will soon be published.

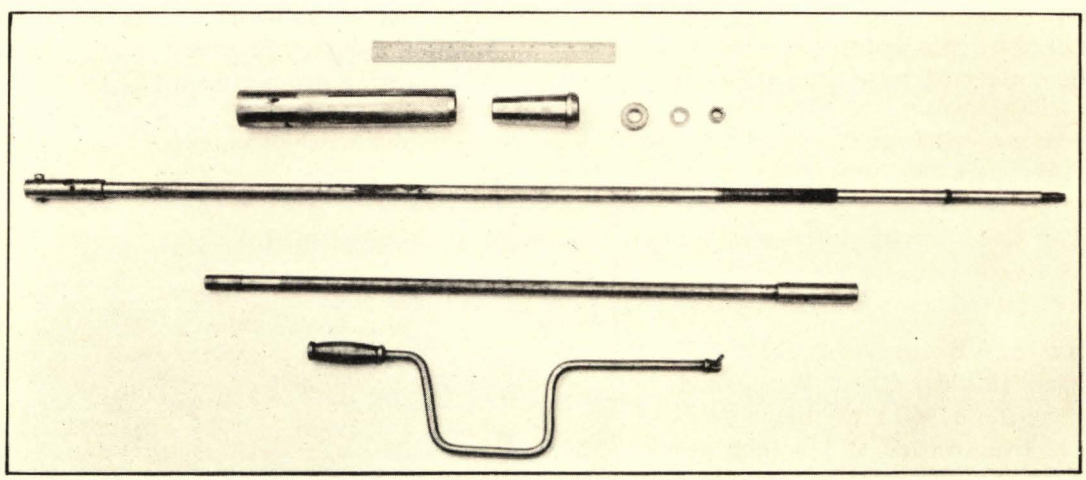

Figure 17.--Components of the tube straightener used to remove dents from installed access moisture tubes.

# publications

BAILEY, REED W., and OTIS L. COPELAND. Vegetation and engineering structures in flood and erosion control. Internatl. Union Forest Res. Organ. Proc. 1962. Band 1: 11-1, 25 pp., illus. (No reprints)

Describes the complementary action of vegetation and structures in controlling erosion and floods on watersheds that have been damaged through use.

BARNES, BURTON V., and R. T. BINGHAM. Juvenile performance of hybrids between western and eastern white pine. Research Note 104, 8 pp., illus.

U.S. FOREST SERV. INTERMOUNTAIN FOREST & RANGE EXP. STA

At three sites in northern Idaho, two Pinus monticola X P. strobus hybrid progenies were approximately twice as tall and markedly excelled corresponding P. monticola progenies (having the same female parents) in height growth at 8 years. At one site in western Montana none of the few P. monticola, P. strobus, and hybrid progenies performed satisfactorily.

BARNES, BURTON V., R. T. BINGHAM, and JOHN A. SCHENK. Insect-caused loss to western white pine cones. Research Note 102, 7 pp.

Insects of three genera, Conophthorus, Dioryctria, and Eucosma, have caused severe loss to cone crops of western white pine in two areas of northern Idaho.

BARNES, BURTON V., R. T. BINGHAM, and A. E. SQUILLACE. Selective fertilization in Pinus monticola Dougl. II. Results of additional tests. Silvae Genetica 11: 89-124, illus.

Tests were made to determine the extent of reproductive discrimination between competing self- and outcross-pollens of western white pine trees. Two seed trees were termed "completely self-fertile" and two trees were termed "partially self-fertile." However, most western white pine trees show a moderate to strong discrimination against self-pollen.

BARNEY, RICHARD J. Appalachian scale shelter. Research Note 88, 7 pp., illus.

Describes a low-cost prefabricated shelter designed to house an Appalachian-type scale; includes detailed drawings.

BARROWS, J. S. Control of lightning fires in American forests. Fifth World Forestry Cong. Proc. 1960, 2: 851-856. (No reprints)

Reviews the magnitude and character of lightning fire control problems in American forests. Summarizes progress of Project Skyfire lightning research program and the general methods of lightning fire control.

BARROWS, J. S. Taming lightning storms . . . Project Skyfire. British Columbia Lumberman 46(4): 26-28, illus.

Describes objectives and progress of Project Skyfire's weather modification program during the 1961 field season.

BARROWS, J. S. The Northern Forest Fire Laboratory program. West. Forestry and Conserv. Assoc., West. Forest Fire Res. Council Proc., pp. 9-12.

Summarizes the Northern Forest Fire Laboratory's research program and project objectives.

BEAUFAIT, WILLIAM R. Procedures in prescribed burning for jack pine regeneration. Mich. Col. Min. and Tech. Bul. 9, 39 pp., illus. (No reprints)

Characteristics of serotinous-coned species suggest use of prescribed fire to facilitate regeneration. Recommendations are made on seed tree selection, fuel preparation, and fire operation.

BEAUFAIT, WILLIAM R. Some effects of prescribed burning on the subsequent development of Pinus banksiana seedlings. Bul. Ecol. Soc. Amer. 43(3): 74. (Paper presented at joint meeting AIBS and AAAS, Corvallis, Oregon, August 1962.)

Identification of the critical stages in first-year seedling development provides guides for timing and intensity of prescribed fires so as to reduce likelihood of adverse effects of heat on the subsequent crop of seedlings.

(CALLAHAM, ROBERT Z.)* Geographic variability in growth of forest trees. Ch. 20, pp. 311-325. IN: Tree Growth, 442 pp., illus., edited by Theodore T. Kozlowski; New York: Ronald Press. (No reprints)

Elaborates the theme that tree growth, like all other plant characters, results from interaction of genes and environment and that the genes, environment, and interaction are not the same for every individual of a species.

COLE, WALTER E. The effects of intraspecific competition within mountain pine beetle broods under laboratory conditions. Research Note 97, 4 pp.
U.S. Forest Serv. Intermountain Forest & Range Exp. Sta.
Intraspecific competition appears to be an important factor limiting mountain pine beetle populations under laboratory conditions. As intensity of attack per unit area of bark surface increases, shorter egg galleries are produced; brood mortality prior to adult emergence increases; and fewer beetles are produced per attack.

COPELAND, OTIS L., JR. Relation of forest diseases to soils and soil management. Fifth World Forestry Cong. Proc. 1960, 1: 518-524, illus. (No reprints)

Discusses different soil conditions as they influence the incidence of major forest tree diseases. Suggests soil management practices that may prevent or alleviate outbreaks of diseases and their severity.

COPELAND, OTIS L., JR., and (R. G. McALPINE). Soil characteristics associated with spot die-out in loblolly pine plantations. Forest Sci. 8: 12-15.

Studies indicate that spot die-out results from a combination of unfavorable edaphic factors rather than from any specific causal organism.

CURTIS, JAMES D., and MARVIN W. FOILES. Damage to ponderosa pine plantations. Research Note 87, 2 pp.
U.S. Forest Serv. Intermountain Forest & Range Exp. Sta.
Describes damage to plantations less than 7 years old by insects and hares in central Idaho.

DENTON, ROBERT E., and HAROLD R. DODGE. Observations on Laspeyresia fletcherana (Kearfott) (Lepidoptera: Olethreutidae) in Montana. Canad. Ent. 94: 102-105, illus.

Describes a bark moth reared from the bark of Douglas-fir in Montana. This is the first record of the host plant, the first specimens of this species received by the U.S. National Museum, and the first known collection of the female.

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* Parentheses indicate authors who are not members of the Intermountain Station staff.

DIVISION OF FOREST ECONOMICS RESEARCH and DIVISION OF FOREST MANAGEMENT RESEARCH. Developing the data framework for effective timber management. Misc. Pub. 25, 13+ pp., illus.

Considers the problem of timber inventory procedures and statistics from the standpoint of developing a data structure for management controls in addition to determining the area and volume of timber in different categories.

FAHNESTOCK, GEORGE R., and JOHN H. DIETERICH. Logging slash flammability after five years. Research Paper 70, 15+ pp., illus.

Reports the results of field tests of flammability of logging slash of nine western tree species after five years of aging.

FERGUSON, ROBERT B. Growth of single bitterbrush plants vs. multiple groups established by direct seeding. Research Note 90, 2 pp.
U.S. Forest Serv. Intermountain Forest & Range Exp. Sta
Describes techniques for direct seeding. At the end of five growing seasons, browse production was essentially the same from single-seeding and multiple groups.

FOILES, MARVIN W. An appraisal of logging damage to advance reproduction of ponderosa pine. Research Note 99, 4 pp.
U.S. Forest Serv. Intermountain Forest & Range Exp. Sta
Heavy cutting in ponderosa pine stands in central Idaho caused significantly greater damage to the understory than light cutting. Damage was nearly the same for stands marked by group selection and stem selection, logged by large and small tractors, and with original overstory volumes of 10,000 to more than 20,000 board feet per acre.

FUQUAY, DONALD M. Mountain thunderstorms and forest fires. Weatherwise 15: 149-153, illus.

Describes the occurrence of forest fires and lightning storms in the northern Rocky Mountains and describes physical and lightning characteristics of storms. Presents physical and electrical model of a typical mountain thunderstorm.

FUQUAY, DONALD M. Project Skyfire Progress Report, 1958-1960. Research Paper 71, 40 pp., illus.

A summary report of Project Skyfire lightning research for the period 1958 through 1960. Includes the general objectives, experimental design, and results of the investigation of lightning storm characteristics and the effect of cloud seeding on lightning occurrence.

FURNISS, MALCOLM M. A circular punch for cutting samples of bark infested with beetles. Canad. Ent. 94: 959-963, illus.

Describes construction and operation of a circular punch used to sample bark beetle populations. Demonstrates advantages of the punch and compares its efficiency to that of other tools which cut larger sampling units.

FURNISS, MALCOLM M. Effectiveness of DDT for preventing infestation of green logs by the Douglas-fir beetle. Research Note 96, 10 pp., illus.

The number of egg galleries and progeny in green logs was reduced significantly by application of a 2% DDT emulsion spray. Discusses methods used to evaluate effectiveness of the spray.

FURNISS, MALCOLM M. Infestation patterns of the Douglas-fir beetle in standing and windthrown trees in southern Idaho. Jour. Econ. Ent. 55: 486-491, illus.

Describes characteristic zones of infestation in standing and windthrown trees as an aid to efficient population sampling.

GORDON, C. C.[1] and (O. L. STEIN). The use of tritiated uridine as a marker in studies of fungal life cycles. Radiation Bot. 2: 7-8, illus.

Describes procedures using labeled uridine to study hyphae within host tissue and to help clarify host-parasite relations.

GRAHAM, DONALD P., and WILLIAM E. FRAZIER.[1] Dwarfmistletoe survey in northeastern Washington. Research Note 103, 8 pp., illus.

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Describes distribution and severity of dwarfmistletoe infection in forest stands of the Colville National Forest and adjacent private lands in northeastern Washington.

HANOVER, JAMES W. Clonal variation in western white pine. I. Graftability. Research Note 101, 4 pp., illus.

Discusses some reasons for success or failure in graftability of different clones of western white pine.

HARDY, CHARLES E., RICHARD C. ROTHERMEL, and JAMES B. DAVIS. Evaluation of forest fire retardants--a test of chemicals on laboratory fires. Research Paper 64, 33+ pp., illus.

Relative effectiveness of seven fire-retardant chemicals was evaluated under laboratory-controlled atmospheric and fuel conditions. Definite differences between the types of retardant materials appeared in the testing operation.

HARTMAN, H. J.[1] Antibiotic control of white pine blister rust. Ninth West. Internatl. Forest Dis. Work Conf. Proc., pp. 29-31. (No reprints)

Discusses antibiotics as a new agent in control of white pine blister rust and the impact that their use would have in modifying the present control program.

HAUPT, HAROLD F. Overland flow, infiltration, and soil movement studies on snow-covered and frozen terrain in the east Sierra Nevada. Amer. Geophys. Union Ann. Meeting Program, p. 77. (Abs.) (No reprints)

Reports results obtained from simulated warm winter rain tests on snowpacks and frozen soils. Minimum infiltration capacities were determined and were related to ground cover, absence or presence of contour furrows, type of soil frost, and season of year. An equation related the amount of soil eroded to the amount of overland flow.

(HAWKSWORTH, FRANK G.), and JAMES L. MIELKE. A witches' broom of Gambel oak associated with Articularia quercina var. minor. Phytopathology 52: 451-454, illus. (No reprints)

Describes a previously unreported witches' broom on Gambel oak, its distribution, damage, and probable causal agent.

HIRSCH, STANLEY N. Infrared as a fire control tool. West. Forestry and Conserv. Assoc., West. Forest Fire Res. Council Proc., 10 pp.

Infrared holds great potential for the improvement of fire detection methods. The major effort in fire research at the Northern Forest Fire Laboratory will be directed toward these problems.

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[1] Cooperator.

HIRSCH, STANLEY N. Possible application of electronic devices to forest fire detection. Research Note 91, 8 pp.

Outlines relative merits of radar and sferics for lightning storm tracking. Discusses the problems of using infrared fire detection.

HOLMES, JOHN R. B.,[1] and DAVID TACKLE. Height growth of lodgepole pine in Montana related to soil and stand factors. Mont. State Univ. Bul. 21, 12 pp., illus.

Multiple linear regression analyses were used to relate soil and stand factors to height growth of even-aged lodgepole pine. Stand factors alone accounted for an exceptionally high percentage of variation in height of sample trees. Describes soils of the study areas.

HUTCHINGS, SELAR S. Measuring plant vigor. IN: Range Research Basic Problems and Techniques. Natl. Acad. Sci., Natl. Res. Council, Pub. 890, ch. 3, pp. 77-80.

Defines the term "plant vigor," and describes criteria and methods of measuring it. Includes a discussion of factors that contribute to plant vigor. (No reprints)

HUTCHISON, S. BLAIR. Recreation opportunities and problems in the National Forests of the Northern and Intermountain Regions. Research Paper 66, 34+ pp., illus.

A discussion of recreation on the National Forests, the land use and development problems surrounding this use, and the opportunities for increasing the contribution of the National Forests to outdoor recreation.

HUTCHISON, S. BLAIR and ARTHUR L. ROE. Management for commercial timber. Clark Fork Unit, Montana. Research Paper 65, 29+ pp., illus.

Considers what a mounting need for wood, the qualities of the local species, and the economics of management seem to point to in the way of a forestry program for the Clark Fork country of western Montana.

JOHNSON, PHILIP C. The incidence of bark beetle susceptibility in old-growth ponderosa pine trees in western Montana. (Abs.) Northwest Sci. 36: 19-20. (No reprints)

Describes the structure of stands in terms of trees of varying susceptibility, or risk, to attack by the western pine beetle, Dendroctonus brevicomis Leconte, together with provisional results of a study to determine the rate and consistency with which these trees are attacked.

JULANDER, ODELL. Range management in relation to mule deer habitat and herd productivity in Utah. Jour. Range Mangt. 15: 278-281, illus.

Overgrazing by livestock has harmfully changed mule deer habitat. Such ranges lack quality forage necessary for critical early spring, fawning, and breeding seasons. Thus herd productivity is reduced. Maximum winter deer populations are now chiefly limited by the amount of current forage growth.

KIMMEY, JAMES W. Comments on new approaches to forest disease control by chemicals. Fifth World Forestry Cong. Proc. 1960, 2: 922-923. (No reprints)

Summarizes the economics and practicability of chemical control of forest tree diseases, and predicts future trends in this control method.

KIMMEY, J. W. Dwarfmistletoe control--the practical approach. Ninth West. Internatl. Forest Dis. Work Conf. Proc., pp. 19-23. (No reprints)

Outlines procedures for forest managers to follow in reducing dwarfmistletoe damage or eliminating it from future forest stands.

KLEMMEDSON, J. O., [A. M. SCHULTZ, H. JENNY, and H. H. BISWELL ].[1] Effect of prescribed burning of forest litter on total soil nitrogen. Soil Sci. Amer. Proc. 26: 200-202. (No reprints)

Standard soil columns were placed under ponderosa forest and subjected to three burning treatments and three periods following burning. All burning and postburning treatments showed net gains of nitrogen: no-burn and light-burn treatments showed greater gain than intense burning. Combined effects of light and intense burning reduced nitrogen in the forest floor by 124 pounds per acre.

KREBILL, R. G., and R. F. PATTON.[1] Wounds in jackpine roots as entry points for a succession of fungi. (Abs.) Phytopathology 52: 739. (No reprints)

Suggests that wounds are necessary before entry and establishment by several root inhabiting organisms is possible, that a fungal succession follows wounding, and that wood decay organisms are usually among the last inhabitors.

LAYCOCK, WILLIAM A. Rotation allows heavier grazing of sagebrush-grass range. Natl. Wool Grower 52: 16-17.

Studies at the U.S. Sheep Experiment Station, Dubois, Idaho, have shown that ranges were greatly impaired when stocked at 20 sheep days per acre each spring without application of rotational or deferred grazing. In recent studies where rotational grazing was used, range pastures were not injured by grazing when stocked at 40 sheep days per acre. Under rotational grazing, stocking rates of 20 and 40 sheep days per acre gave equally favorable results.

LOWERY, DAVID P. Service records on treated and untreated wood in the Intermountain West. Research Note 92, 7 pp.

Summarizes the results of durability tests of fenceposts, poles, pole stubs, and railroad ties dating back to 1909. Practically all native species were tested using four treating methods and eight different preservatives.

LYNCH, DONALD W. Measuring and predicting growth of even-aged stands. Ch. 25, pp. 401-415. IN: Tree Growth, 442 pp., illus., edited by Theodore T. Kozlowski; New York: Ronald Press. (No reprints)

Describes and appraises the more important methods of measuring and predicting growth of even-aged stands.

MERRIAM, ROBERT A. Useful statistical guides and graphs for neutron probe soil moisture sampling. Research Paper 62, 10 pp., illus.

Graphs are presented to permit determination of counting time required for given levels of reliability considering random errors in use of the neutron probe for soil moisture measurements.

MILLER, ORSON K., JR. Sporulation, germination, and early growth of Echinodontium tinctorium. Plant Dis. Rptr. 46: 576-578, illus.

Reports successful germination of the basidiospores, their viability, and early growth of their germ tubes.

MOESSNER, KARL E. Preliminary aerial volume tables for pinyon-juniper stands. Research Paper 69, 12 pp., illus.

U.S. Forest Serv. Intermountain Forest & Range Exp. Sta.

Describes techniques for rapid and inexpensive estimation of wood volumes in stands of these species that are widely scattered in the Southwest.

MOESSNER, KARL E. Bar-type micrometer wedge. Research Note 93, 2 pp., illus.

This wedge, patterned after dot and line type wedges used in measuring crown diameters, was developed for measuring stream width. It allows precise measurement of photo distances to the nearest 0.0002 foot.

MOESSNER, KARL E. Revised aerial photo-scale protractor. Research Note 95, 2 pp., illus.

Revised photo scale protractors include scales graduated in feet instead of chains, and azimuth as well as quadrant protractors. The No. 15 and No. 10 scales can now be ordered in chains or feet and with quadrant or azimuth protractors.

MOESSNER, KARL E., and STEWART ROSS TOCHER. Parallax wedge improved. Research Note 94, 2 pp., illus.

Improved parallax wedge includes plot circles and 0.001-foot scales needed in measuring horizontal distances when computing slope percent.

[MORRIS, M. S., J. E. SCHMAUTZ ],[1] and P. F. STICKNEY. Winter field key to the native shrubs of Montana. Montana Forest and Conserv. Expt. Sta. Bul. 23, 70 pp., illus.

This nontechnical guide for identifying Montana shrubs in winter condition was designed for use in the field. Aids to identification, in addition to the keys, include a section on the ecology of shrub distribution, descriptions of individual species, and line drawings of distinguishing or "key" characters for these species. Indicates value to wildlife or livestock for most of the shrubs.

MUEGGLER, WALTER F. Range resources and management problems in northern Idaho and northeastern Washington. Research Paper 68, 31 pp., illus.

Discusses grazing types and problems requiring research on both livestock and big-game ranges in northern Idaho and northeastern Washington.

MURRAY, ROBERT B., JR. A study of range condition in a fescue grassland in western Montana. Abstract of M.S. Thesis. Jour. Range Mangt. 15: 58-59. (No reprints)

Forage production was 592.2, 303.2, and 216.9 pounds per acre in excellent, fair, and poor range. Festuca scabrella produced 64 percent of the forage on excellent condition range. Infiltration measured in September was highest on the excellent condition range and it was comparatively high even on poor condition range.

PACKER, PAUL E. Elevation, aspect, and cover effects on maximum snowpack water content in a western white pine forest. Forest Sci. 8: 225-235, illus.

Nine variables--expressions of elevation, aspect, forest canopy density, and related interactions account for 91.6 percent of the variance in water content of the snowpack. Discussion of variations of effects of these variables shows how forest management can influence snowpack water content.

SCHMIDT, WYMAN C. Rapid viability tests for western larch seed. Montana Acad. Sci. Proc. 21: 26-32, illus.

By cold-soaking western larch seeds in water or by soaking them in hydrogen peroxide prior to incubation, 98 percent of germinative capacity can be reached in as short a time as 28 days.

SHEPHERD, WELDON O. Herbage sampling for yield: natural pastures and range. IN: Pasture and Range Research Techniques. Prepared by a Joint Com. of the Amer. Soc. Agronomy, Amer. Dairy Sci. Assoc., Amer. Soc. of Animal Prod., and ASRM, 1962, pp. 102-105. (No reprints)

Lists and discusses techniques for sampling herbage yields and forage utilization on native range pastures.

SHEPHERD, WELDON O. Root reserve analyses. IN: Range Research Basic Problems and Techniques. Natl. Acad. Sci., Natl. Res. Council, Pub. 890, ch. 4, pp. 86-94. (No reprints)

Basic understanding of chemical, environmental, and physiological plant process is essential to application of range management. Studies of drought, fertility, competition, and other environmental conditions are often dependent on thorough knowledge of root development: depth of penetration, distribution, quantity, and rate of growth. The role of roots in storage of plant food reserves is important in evaluating plant response to environmental factors, especially grazing.

SQUILLACE, A. E., and (ROY R. SILEN). Racial variation in ponderosa pine. Forest Sci. Monog. 2, 27+ pp., illus.

Data from two ponderosa pine provenance studies conducted in northern Idaho and in Oregon and Washington were analyzed in detail. Results verify apparent differences in growth rate found earlier and correlate these differences with various geographic and climatic factors of the seed source localities.

STAGE, ALBERT R. Tables for point-sampling cruising in ponderosa pine. Research Paper 63, 15 pp.
U.S. Forest Serv. Intermountain Forest & Range Exp. Sta.
A compilation of tables to aid foresters in cruising ponderosa pine by the point-sampling method.

STAGE, ALBERT R. A field test of point-sample cruising. Research Paper 67, 17+ pp., illus.

A prism having a basal-area factor of 25 appears to be most suitable for general use in northern Rocky Mountain forests. Marginal trees should be checked for tallying by careful measurements to avoid bias in the basal-area estimate.

STATION STAFF. Annual report, 1961.

Reports year's activities of the Intermountain Station.

TACKLE, DAVID. Infiltration in a western larch--Douglas-fir stand following cutting and slash treatment. Research Note 89, 7 pp., illus.

The first year after logging, the infiltration capacity of skid roads, scarified areas, and broadcast burned surfaces averaged 4.1, 15.4, and 62.5 percent, respectively, of the capacity of undisturbed soil. During the succeeding 4 years the water intake capacity of scarified and lightly burned surfaces improved fairly rapidly, but skid roads showed virtually no improvement.

TACKLE, DAVID. Specific gravity of lodgepole pine in the Intermountain region. Research Note 100, 4 pp., illus.
U.S. Forest Serv. Intermountain Forest & Range Exp. Sta.
Specific gravity at breast height, calculated by the increment core method, gives a satisfactory estimate of average tree specific gravity. Specific gravity decreases noticeably from stump height up to 20 feet, but changes little above that.

TAYLOR, ALAN RAY. Lightning damage to Douglas-fir trees in southwestern Montana. (Published as thesis for the degree of Master of Science in Forestry, Montana State University, 1962.) (No reprints)

Analyzes the characteristics of lightning damage to Douglas-fir trees as investigated in connection with Project Skyfire. Drawings show nature of lightning damage. Summarizes relations of tree characteristics to lightning strikes.

THYR, B. D.[1] A taxonomic review of Actinothyrium marginatum. (Abs.) Phytopathology 52: 755. (No reprints)

Discusses the classification of the red band fungus that causes an important foliage disease of ponderosa and lodgepole pine in northern Idaho.

WATERS, CHARLES W.[1] Significance of life history studies of Elytroderma deformans. Forest Sci. 8: 250-254, illus.

Describes the unique systemic spread of the fungus in needle, twig, and bud tissue of ponderosa pine and clarifies a previously unknown portion of the life cycle of the fungus.

WELLNER, CHARLES A. Silvics of western white pine. Misc. Pub. 26, 24 pp., illus.

Describes distribution, habitat conditions, life history, and races based on selected references and unpublished data through 1962.

WICKER, ED F. Rapid germination as a viability test for seed of Arceuthobium spp. (Abs.) Phytopathology 52: 757. (No reprints)

Discusses the use of hydrogen peroxide as a procedure for testing viability as well as germination of dwarfmistletoe seeds in contrast to staining techniques.

WICKER, ED F., and CHARLES GARDNER SHAW.[1] Fungi which provide some local biological control of Arceuthobium spp. in the Pacific Northwest. (Abs.) Phytopathology 52: 757. (No reprints)

Describes the fungus parasites of several dwarfmistletoe species.

WILSON, ALVIN K. Timber resources of Idaho. Forest Survey Release 3, 42+ pp., illus.

Timber inventory and timber cut statistics from most recent surveys of northern and southern Idaho are brought together and discussed in relation to recent forest industry developments. Includes a forest type map of Idaho and 27 tables of statistics for forest areas, volumes, growth, and timber products output.

WILSON, ALVIN K. Forest products output in Utah in 1960. Forest Survey Release 4, 8 pp.

Nearly 15 million cubic feet of timber were cut for sawlogs, mine timbers, and other primary forest products. Lumber production, estimated to be 69,298,000 board feet, consumed more than 85 percent of the total timber cut.

WILSON, ALVIN K. Production of lumber and other forest products in Nevada, 1960. Forest Survey Release 5, 3 pp.

Nearly 3.2 million cubic feet of roundwood products were cut from Nevada's forests in 1960. Lumber production was estimated to be 33.9 million board feet; a large share was sawed from logs imported from California.

WILSON, ALVIN K. Severe decline in Montana Christmas tree shipments. Research Note 98, 4 pp., illus.

The annual survey showed that, although 2.4 million trees were shipped in 1961, exports were 25 percent below the 1960 level and had fallen to the lowest point since 1942, when annual surveys were started.

WRIGHT, HENRY A. Influence of fire on important bunchgrasses of the sagebrush-grass region of southern Idaho. M.S. Thesis, Utah State University, Logan.

Four species of bunchgrass (Poa secunda, Sitanion hystrix, Stipa comata, and Stipa thurberiana) were tested at two intensities for resistance to fire damage. Fire injured both Stipa species, but S. comata was the more susceptible. Most burning treatments caused heavy mortality and reduction of basal area.

The Intermountain Forest and Range Experiment Station, U. S. Forest Service, has headquarters in Ogden, Utah, and field offices at:

Boise, Idaho

Bozeman, Montana (in cooperation with Montana State College)

Ephraim, Utah

Logan, Utah (in cooperation with Utah State University)

Missoula, Montana (in cooperation with Montana State University)

Moscow, Idaho (in cooperation with the University of Idaho)

Provo, Utah

Reno, Nevada (in cooperation with the University of Nevada)

Spokane, Washington

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